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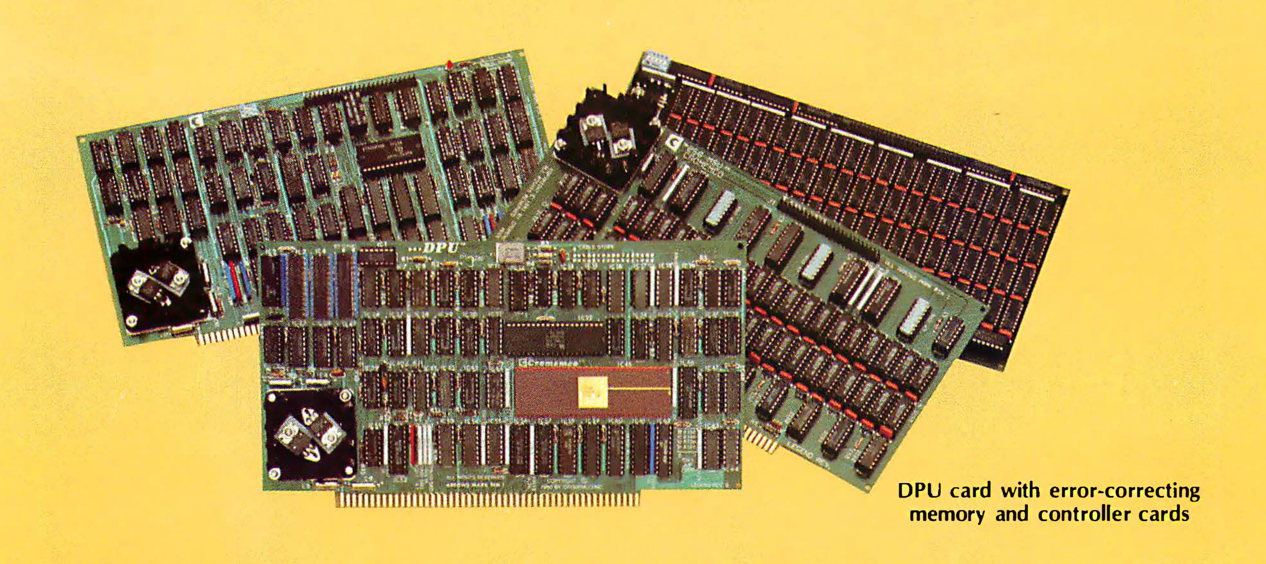
the small systems journal

September 1982 Vol. 7, No. 9
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Computers and the Disabled

ROBERT & TINNEY

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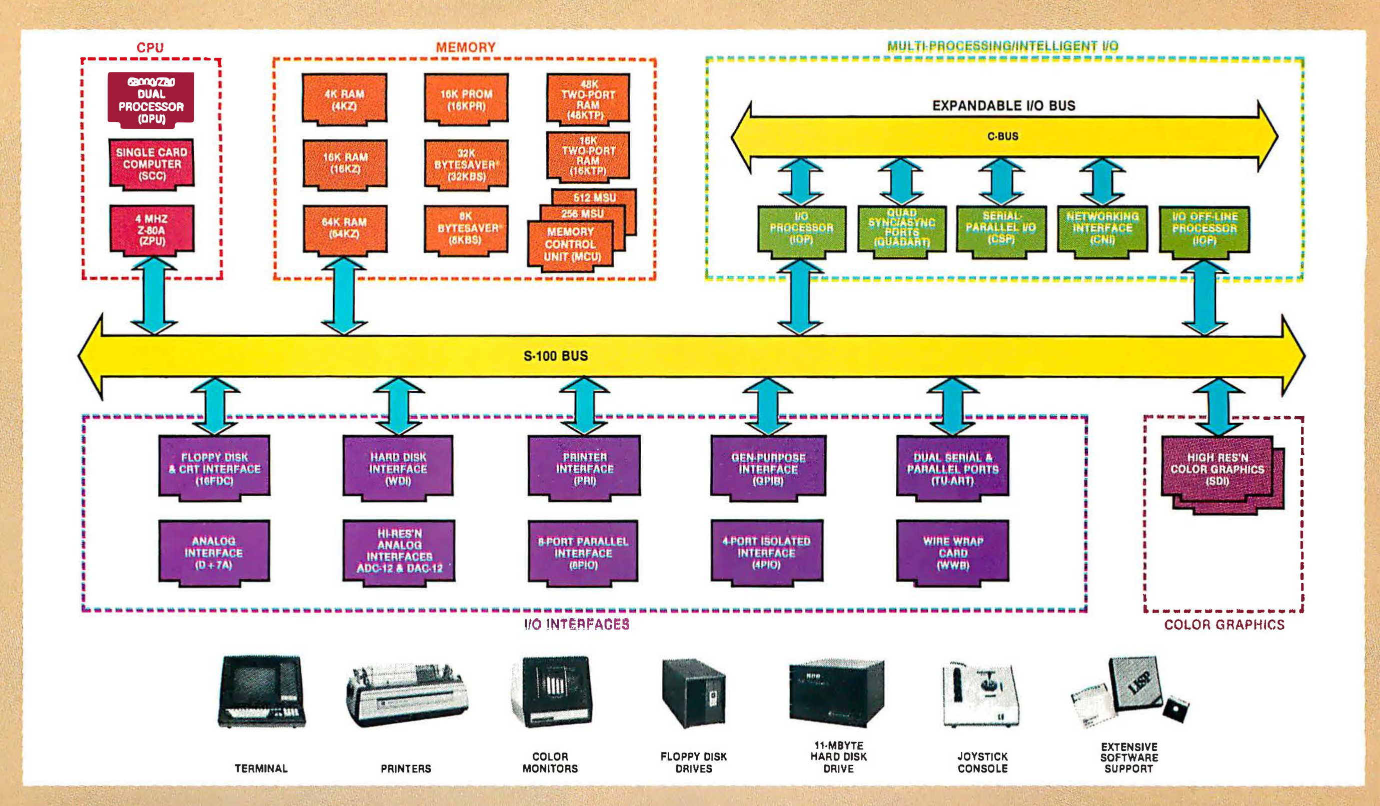
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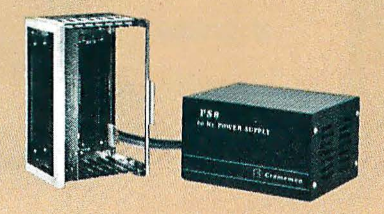
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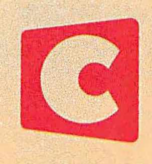
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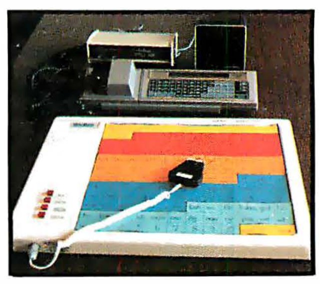


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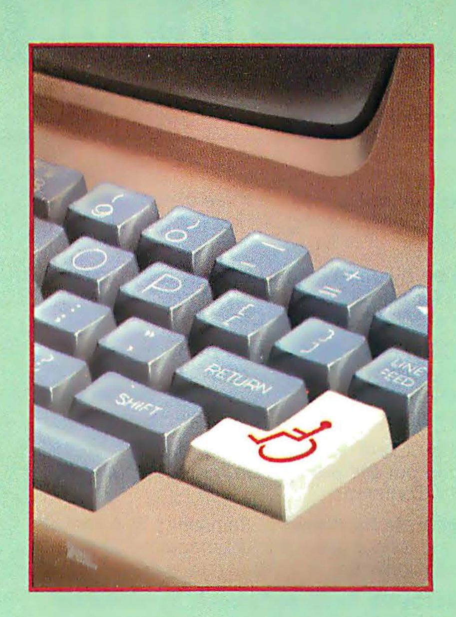


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In This Issue

BYTE marks its seventh anniversary with the theme Computers and the Disabled, graphically illustrated on the cover by Robert Tinney. Gregg Vanderheiden discusses how "Computers Can Play a Dual Role for the Disabled," and with coauthor Paul Schwejda demonstrates how to make an "Adaptive Firmware Card for the Apple II." David Stoffel reviews talking terminals for the blind, and William L. Rush evaluates the Abilityphone, a device for nonvocal communication. Patrick Demasco and Richard Foulds show how the Panasonic Hand-Held Computer can be used as a communication device in "A New Horizon for Nonvocal Communication Devices." Steve Ciarcia brings you his latest speech-synthesis system in "Build the Microvox Text-to-Speech Synthesizer: Part 1—The Hardware," and Dr. William Murray reviews The Cognivox VI-1003, a speech-recognition system. Bruce Baker discusses his highly original Minspeak associative memory system for portable speech synthesis, and Alfred Fant Jr. shows you how to use a line printer to produce braille. In case you're thinking of marketing your own computerized aid, see our overview of the FDA's regulations concerning medical devices. In addition to our regular articles and reviews, we have BYTE's Arcade, and we start the countdown on our game contest winners.

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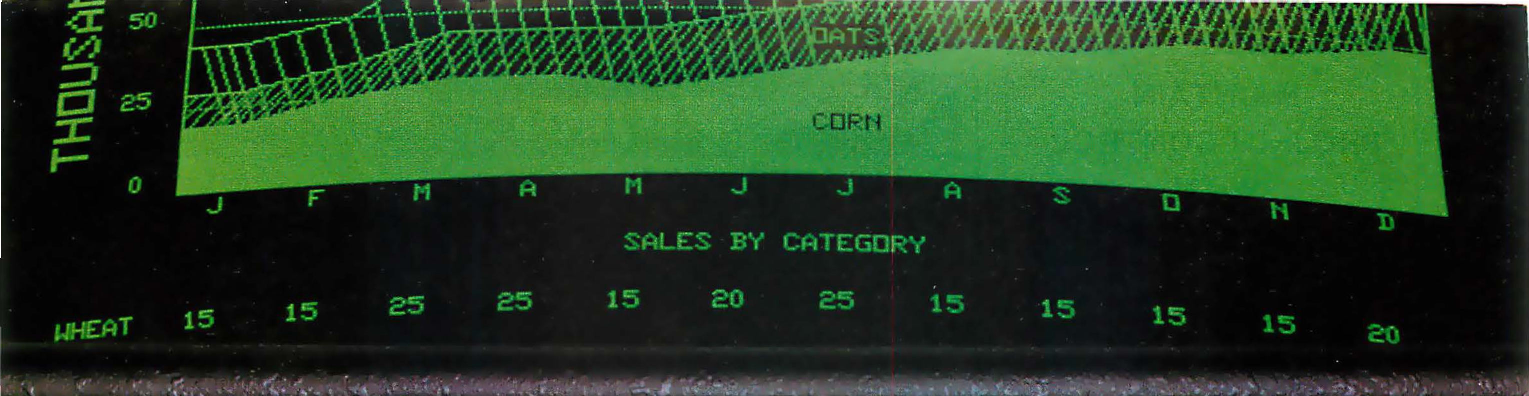
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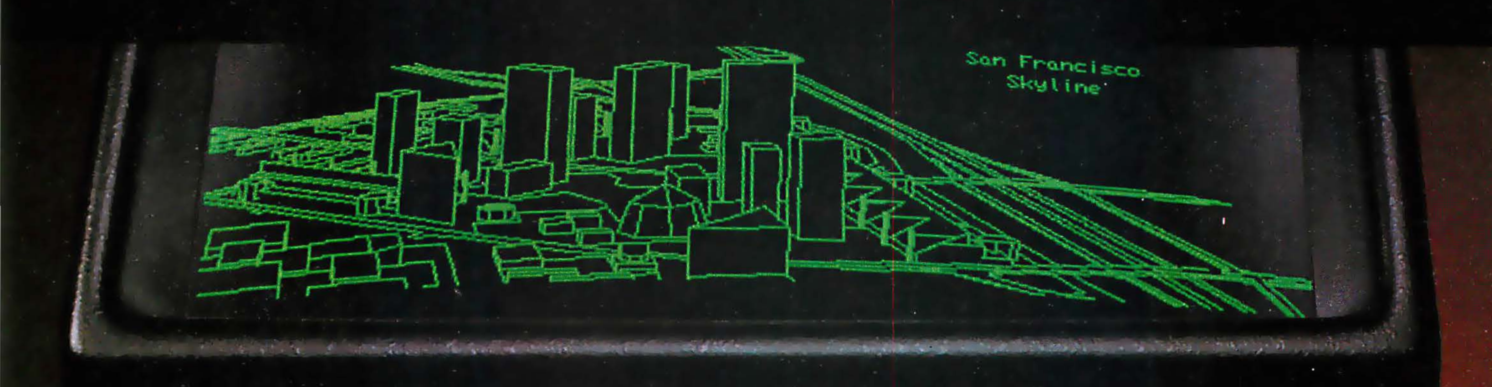
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Editorial

Let There Be Talking People Too

by Mark Dahmke, Consulting Editor

When I was in college I met a fellow student who had great difficulties communicating because of cerebral palsy. We became friends and as things turned out I designed a voice-synthesizer system that greatly enhanced his ability to communicate. Designing this device was a logical extension of my long-time interest in electronics, microcomputers, and voice synthesis. My friend's case is a good example of how artificial aids—communicative or otherwise—can improve the quality of life for disabled persons.

Personal computers have done more for people with communicative disorders than any other technological development. Microcomputers are versatile machines that can be customized fairly easily to fit the individual needs of each person. Computers can be programmed to accept input from any kind of switch or device and to interpret that input in whatever way the user wants. As well, they can be made to respond with visual or audible output, opening up a new world to deaf and blind individuals.

Nearly 500,000 Americans who are not classified as retarded are unable to communicate either vocally or with standard hand signs. An even more sobering thought is that perhaps 100,000 or more individuals of normal intelligence are in institutions and have been diagnosed as retarded simply because they do not have the physical means to communicate. We do not even have accurate statistics in this area because of the nature of the disability. Assuming that the number of people with communicative disorders in this country amounts to two tenths of 1 percent of the population, then about 10 million people are affected world-wide.

While we now have the technology to *build* devices to compensate for almost any communicative disability, not everyone who needs a communication aid can *afford* one. They can't be mass produced because (ideally) they all require some customization. A similar situation prevails in the case of artificial limbs. Each prosthesis can cost thousands of dollars because of the relatively small market and because each limb is handmade for the individual. What we need are standard devices with plug-in memory modules, plug-in keyboard layouts, and modular-display or audio-output options. A communication aid could then be put together easily from two or three standardized modules and would fill 90 percent of the needs of most individuals with communication problems.

One highly successful device currently on the market is the Texas Instruments Speak & Spell, which was designed as a children's learning tool. It has a reasonably large vocabulary and costs around $50. In its current configuration, it can work as a communication aid if you ignore the spelling mode and simply type messages letter by letter. If, however, a few extra features had been incorporated into its design it could have very easily functioned as a communication aid and still cost $50. It would have been the case of a mass-market product (with the price benefits of economies of scale and an extensive advertising campaign) doubling as a special-needs device. The integration of general-appeal consumer products with limited-market special-needs devices should be our goal. Thousands of people would benefit.

Recently Texas Instruments announced a new product called Vocaid, based on its Touch & Tell product. The $150 device can be used by people with short-term communications problems. It also is a great communication aid for anyone with reasonably good coordination and cognitive skills. It can also accept memory modules that have specialized vocabularies. As such, it is a good practical application of customizing a standard product by plugging in memory modules.

Part of the problem faced by disabled individuals is the way they are perceived by the able-bodied members of society. Today we scarcely think of someone who wears eyeglasses as disabled, yet before the discovery of the principles of optics, people with vision problems surely would not have been able to lead normal productive lives. I hope that in a similar way microcomputers will be able to help people with physical limitations overcome the restrictions to activity imposed on them by their disabilities and become, remain, and be viewed as productive members of society. It is an encouraging sign to see the proverbial "synthesizer on a chip." And now that we have the technology we must accept the challenge of making the fruits of that technology available to the people who will benefit the most.

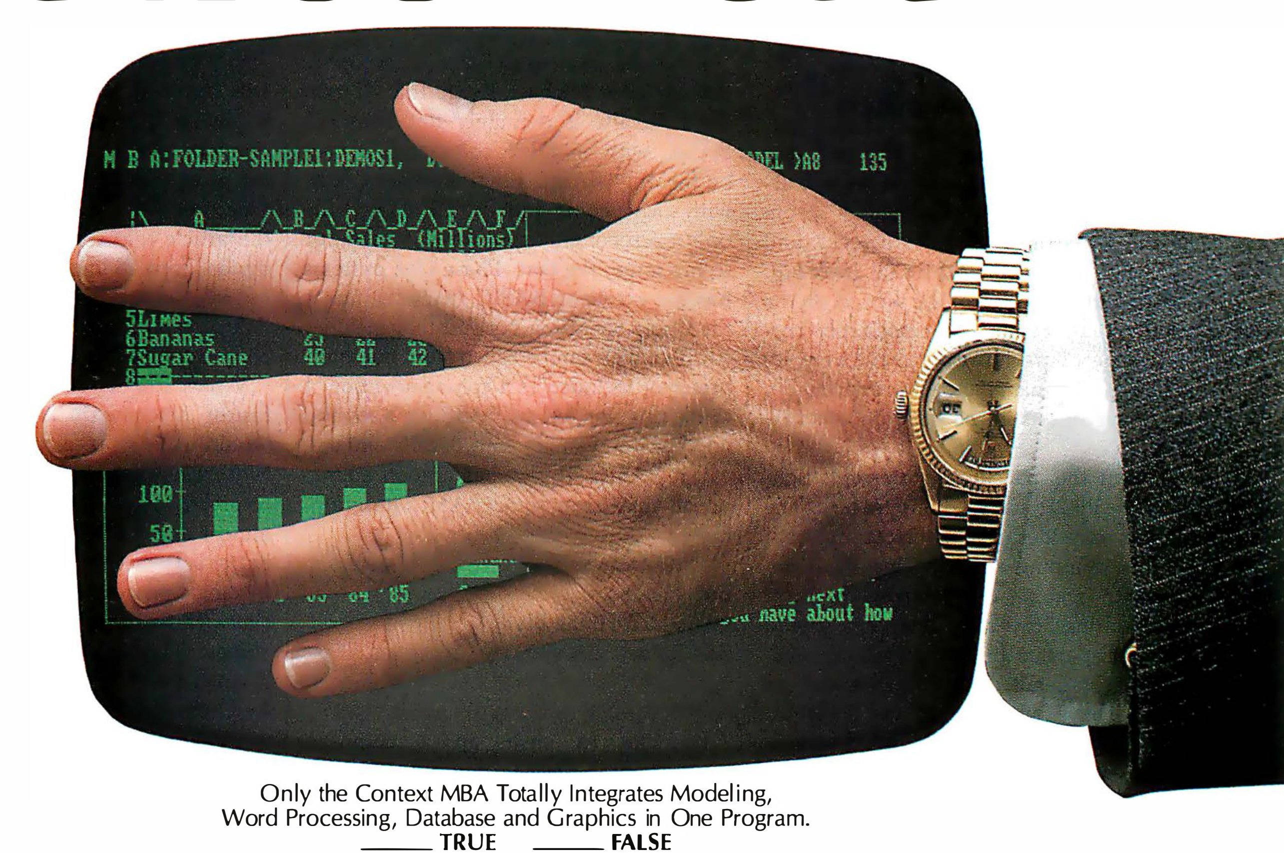
On "Finding A Voice," a recent episode of NOVA on public television, John Eulenburg of Michigan State University said, "If there are going to be talking microwave ovens, let there be talking people too."■

Articles Policy

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Response to Japanese Computers

As a BMC if800 user for the past year and a half, I read with interest the fine article "Six Personal Computers from Japan" by Christopher P. Kocher and Michael Keith (May 1982 BYTE, page 60). I was pleased to see that the section on the if800 was thorough and reasonably correct. The authors, however, made a few inaccurate statements that were probably due to omissions in the if800 documentation.

One of the inaccurate statements concerns the if800's screen-dump feature. The authors consider it a shortcoming that ". . . in dumping a screen image (as opposed to regular character-by-character text printing) the scan lines are spread quite far apart in the printed image, making text or detailed graphics difficult to read." They fail to mention, however, that the if800 has two additional screen-dump modes—one that prints a normal representation of what appears on the screen without the above-mentioned wide spacing, and another that prints a compacted representation of what appears on the screen. The widely spaced printout described in the article is obtained by pressing the Hard Copy key. The normally spaced printout is obtained by holding down the CTRL (Control) key while pressing the Hard Copy key. Likewise, the compacted printout is obtained by holding down the Shift key while pressing the Hard Copy key.

A second inaccuracy occurs in the subsection titled "Minor Gripes." Here the reader is led to believe that the if800 keyboard functions only in the uppercase mode, where the Shift key must be used to get lowercase characters. The if800 keyboard does, in fact, have a typewriter mode in which the Shift-key function is reversed; that is, lowercase characters are typed when the Shift key is not used, and uppercase characters are typed when the Shift key is used. The typewriter mode may be entered by simply pressing the Shift and COMD (Command) keys simultaneously. To return to the uppercase mode, press the CTRL and COMD keys together.

Ken Davison, Applications Engineer
Oki Semiconductor Inc.
1333 Lawrence Expressway, Suite 401
Santa Clara, CA 95051

I would like to inform Christopher Kocher and Michael Keith that Canon CX-1 BASIC is definitely not the only BASIC with an XREF command. It may be the only BASIC running under CP/M with such a command, but CP/M isn't the only microcomputer operating system, or to my mind, the best. Phase One Systems has an excellent BASIC (running under the Oasis operating system) that includes XREF, which can be called from the interpreter or included as a compiler option. I think this version of BASIC is about as good as you can get with BASIC and still call it BASIC. It also has a good editor, which may stun some BASIC programmers.

Bob Pierce
99 Golden Hinde Blvd.
San Rafael, CA 94903

I'd like to clear up a common misconception about using multiple processors. In the article "Six Personal Computers from Japan," the authors repeatedly state that the Fujitsu FM-8 was the fastest machine in their test due to its "division of labor." A little reflection will reveal this to be false.

As stated in the article, the three microprocessors in the Fujitsu handle processing, video, and keyboard scanning. The authors did not realize that while running a BASIC benchmark the second and third processors are standing by in an idle loop. Because the programs that the authors chose do not involve graphics or extensive character I/O (input/output), they will not exercise the task-splitting features of the FM-8 computer.

As the designer of my own dual-processor upgrade for my SWTPC (Southwest Technical Products Corporation) computer, I've found that speed improvement is seldom a factor. In any program that does extensive computation, the I/O processor remains idle. In programs that do a lot of screen formatting, the main processor must wait. Only in those rare programs where computation and I/O are evenly split does my computer approach a theoretical speed improvement of 2 to 1.

So why do Fujitsu and I use multiple processors? In my case, I wanted to free the computation-processor memory space from the space required for the graphics storage. This use of multiple processors is mentioned in the BYTE article. If an Apple or Radio Shack computer devoted 48K bytes of memory to graphics, there would be little left for the user. The FM-8 graphics resolution of 640 by 200 by 3 bits per pixel adds up to a total of 48K bytes of video memory. It was not mentioned in the article that 640 by 200 pixels can be divided into 25 lines and 80 columns of 8- by 8-bit character cells. This means the Fujitsu can plot letters in graphics with 80 characters per line.

What, then, makes the Fujitsu the fastest machine in the group tested? I would say it is a combination of its Motorola processor and a good BASIC interpreter. I can't overstress the fact that almost any hardware can run faster with better software. My vintage SWTPC 6800 in single-processor mode is about three times faster than the new Japanese machines. This is possibly due to the fast floating-point BASIC interpreter supplied by Technical Systems Consultants.

Leo Taylor
18 Ridge Court West
West Haven, CT 06516

Another TRS-80 Hang-Up

Glenn Tesler's article "TRS-80 BASIC Program Hang-ups: The Reasons and Some Solutions" (May 1982 BYTE, page 318) was very well done and useful. I would like to extend his article with a practical suggestion for other programmers. I have noticed that programs containing PRINTUSING statements that have concatenated strings as statement elements eventually lead to program hang-ups in TRS-80 BASIC. A simple solution is to avoid concatenating strings in these statements by using alternative methods. For example, instead of

```
PRINTUSING"% (20 spaces) %";
  "A"+". "+B$
```

try:

```
PRINTUSING"!";"A";:PRINT". ";:
  PRINTUSING"% (17 spaces) %";
  B$
```

You can use the addresses for "string work area" and "start of string data" pointers given in listing 2 of the article to verify the difference. This technique is

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Thank you for publishing Glenn Tesler's article "TRS-80 BASIC Program Hang-ups: The Reasons and Some Solutions." If anyone wishes to get in touch with Glenn, his correct address is Glenn Tesler, Prosoft, POB 839, North Hollywood, CA 91603.

Your readers might also be interested to know that Glenn was barely 12 years old when he wrote that article.

Although he didn't know it at the time the article was written, Glenn now says that many of the techniques presented in the article apply to Microsoft BASIC on the Apple, the IBM Personal Computer, and many other microcomputers.

Debbie Tesler
Prosoft
POB 839
North Hollywood, CA 91603

Why Advertisers Don't Respond

We read with interest the letter to the editor from H. B. Brandon regarding the lack of interest some advertisers showed concerning inquiries about their equipment or software (May 1982 BYTE, page 19). Our firm specializes in designing and optimizing small computer systems for industry and small-business use. We often experience the same frustration and delay that Mr. Brandon found. Typically, it is not that the manufacturers intend to be rude or inapproachable, but rather that they are simply swamped. For production lines, customer services, sales forces, etc. to be scaled up to meet the demand requires a very long lead time plus long-range forecasting to meet future demand. Personnel must be hired and trained, and telephone lines must be added to handle orders and inquiries. Sometimes the entire staff must be relocated to more spacious quarters. Then of course, letters can be lost. We offer this not as an excuse but as an explanation and ask you not to be too harsh in your judgment of these companies.

Thomas M. Krischan, Chief Executive Officer
Technimetrics Computer Consulting
646 South 93rd St.
West Allis, WI 53214

Buffer Overflow Cure

I enjoyed reading John Blankenship's "Give Your Apple a Voice: A Speech-Development System Using the Radio Shack Speech Synthesizer" (May 1982 BYTE, page 446). However, like most articles on the Radio Shack Speech Synthesizer, it overlooked the fact that this device contains only a 32-byte buffer and has no control over preventing buffer overflow. There is a simple cure for this problem; it requires a small hardware modification to the synthesizer and the availability of a single input line to the computer. First, bring out pin 2 of IC4, as marked on the circuit board, to an unused wire of the ribbon cable. On the computer end of the ribbon cable connect this line to an input port that can be read by your program. The signal you have just wired to an input port will indicate by a low voltage that the synthesizer buffer is full. It will go to a high-voltage state when there is again room in the buffer.

Ralph J. Jannelli
101 Cottonwood Dr.
Jamestown, NC 27282

We congratulate Mr. Blankenship on his excellent article. The program listing he provided should be quite helpful to owners of the Radio Shack Speech Synthesizer. As an update to the article, please note that while the Radio Shack Speech Synthesizer was designed and manufactured by Votrax for Radio Shack, the unit uses a Votrax VST synthesizer module, not an SC-01A speech chip. It may interest your readers to know that the SC-01A is currently available in a Votrax product called Type-'N-Talk, a text-to-speech computer peripheral with unlimited vocabulary and an RS-232C interface. Type-'N-Talk utilizes a program similar to that developed by Mr. Blanken-

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ship for the Radio Shack unit, but the software is self-contained within Type-'N-Talk and requires no additional programming on the part of the user. Mr. Blankenship's statement that "quality was more a function of the programmer than of the hardware" is all too true, but with the introduction of programs such as his for the Radio Shack unit and Type-'N-Talk more and more users can now add voice to their computers without first becoming specialists in phonetic speech synthesis.

Melanie J. Moyna, Manager
Consumer Products Group
Votrax
Division of Federal Screw Works
500 Stephenson Highway
Troy, MI 48084

The Votrax SC-01A chip is also used in Steve Ciarcia's project this month. See "Build the Microvox Text-to-Speech Synthesizer, Part 1: Hardware," on page 64. . . . R.S.S.

Computing Careers

Jacqueline Johnston's article "Career Opportunities in Computing" (April 1982 BYTE, p. 439) was very informative and useful. I enjoyed it because I am currently seeking a job as an entry-level programmer. As a result, I have some observations that may interest the audience addressed by Ms. Johnston's article.

There are indeed many openings out there for programmers and programmer-analysts. This fact is readily apparent from the classified pages of the major metropolitan newspapers. But very few of the advertised openings are for entry-level personnel, and many firms demand qualifications that even an experienced professional may have difficulty meeting.

Entry-level programmers who do not have access to a school placement service or a diligent guidance counselor will probably have to knock on a lot of doors in order to find entry-level positions. This could be an expensive proposition for anyone who resides, as I do, in an area remote from the urban centers where there is the greatest demand for computer personnel. Private employment agencies are of little help because, although clients will pay an agency to find experienced programmers, companies apparently prefer to obtain entry-level personnel through campus recruiting and walk-ins.

Most advertised openings I have seen now specify two to five years' experience in addition to the expected knowledge of a specific computer language. While many hobbyists may meet those qualifications, the job seeker should also realize that most advertisements now demand experience on specific types of computers and knowledge of specific operating and/or database systems. These prerequisites presumably exclude those professionals who are familiar with the "wrong" machine or system. They certainly exclude those hobbyists who have had no opportunity to work with minicomputers and mainframes.

These demands for specialization in one brand or line of hardware or software seem unrealistic. After all, much of what we do as programmers is medium independent, there is a shortage of computer personnel, the differences between brands of hardware and software are not huge, and new brands or lines of hardware and software are coming into the market almost daily. The employers obviously want no time wasted on training or retraining computer personnel; perhaps high salaries are at fault.

These observations are not meant to discourage anyone interested in a programming job or career. The opportunities are out there, but finding a position that's right for you may not be quite as easy or fast as it once was or as some sources would indicate.

La Vaughn H. Hayes
2021 Biltmore Dr.
Fayetteville, NC 28304

Disclaimer May Not Be Valid

I read with interest John Navas's letter regarding warranties and software (May 1982 BYTE, page 18), and I'd like to inform Mr. Navas that just because a disclaimer is printed doesn't mean it is valid.

Assuming Mr. Navas's software can be termed "goods" under the Uniform Commercial Code, Section 2-316 of that code applies. This section requires that for a disclaimer to be valid, it must be conspicuous and in writing.

Conspicuousness in this context is readily determined. Usually the disclaimer must appear in capital letters and in a typeface that contrasts with the surrounding typefaces. If a disclaimer is indistinguishable from the rest of the sales contract or agreement, it is not conspicuous.

Furthermore, it is required that the purchaser either have or should have had actual knowledge of the disclaimer prior to the sale. A warranty cannot be disclaimed after a sale.

Finally, even if there is a disclaimer, the disclaimer will not excuse the failure to supply the goods forming the basis of the bargain. For example, if Mr. Navas bought a checkbook maintenance program, the product must function as a checkbook maintenance program. If the software or hardware delivered is so riddled with bugs that it will not operate, the seller did not deliver what was bargained for.

L. J. Kutten
201 South Central
POB 16185
St. Louis, MO 63105

A Fix for the Soundex Algorithm

The algorithm given in Jacob R. Jacobs's "Finding Words That Sound Alike: The Soundex Algorithm" (March 1982 BYTE, page 473) can be improved simply by eliminating the code element

for vowels only after consecutive repeated elements are eliminated. With this fix, the routine will correctly discriminate between words like "decision" and "thicken" because similarly coded consonants separated by vowels are preserved. The earliest document I know of that describes the Soundex method with this change is "Information Retrieval by Proper Name" by W. L. Hewes and K. H. Stow (June 1965 *Data Processing*, page 18).

John Nesbit
9808 110th St.
Edmonton, Alberta
Canada

Wanted: FORT/80

My company has a problem: a number of our customers have bought and are using FORT/80, a FORTRAN compiler produced by Unified Technologies Inc. of Islington, Ontario. Our customers find the compiler an excellent product, if a little lacking in some advanced features. Unfortunately, we believe Unified Technologies ceased trading some time ago, and we cannot contact them.

We would appreciate any information on the availability of the FORT/80 compiler.

D.G. Collier, Software Director
Data Applications [UK] Ltd.
16B Dyer St.
Cirencester
Gloucestershire, GL7 2PF
United Kingdom

MPI Disk Drives Meet IBM

The following information may be useful to anyone considering purchasing the IBM Personal Computer.

Recently, I decided to upgrade to a 16-bit computer. I first purchased the IBM *Technical Reference* manual and later bought the IBM Personal Computer. Why did I buy the technical manual first? I wanted to know if there was any reason why IBM's Tandon-made disk drives could not be replaced with my MPI (Micro Peripherals Inc.) B51 drives.

Last week, I brought home my newly acquired Personal Computer system with the DOS (disk operating system) manual, a disk-controller board, a color-graphics board, and an additional 16K bytes of memory. That same evening my system was up and running with the DOS and one of the B51 drives. Unfortunately, when I attached the second disk drive neither drive would work. I found that making the MUX (multiplex) connection on the MPI shunt socket for the Tandon drive, as described in the *Technical Reference* manual, does not work on the MPI drives, because the drive electronics are then enabled all the time. Therefore, the outputs of the two drives contend with each other. Fortunately, no damage can occur with open-collector drive circuits. The solution is simple: do not make the MUX shunt connection. Also, the disk-controller board places a logic low voltage on pin 34, Side Select, and this must always be logic high for the MPI B51 drives.

The following information will allow anyone who wants to use MPI B51 drives to have a system up and running in no time with the IBM Personal Computer and DOS:

- Each MPI drive must be set up to receive its Drive Select signal on pin 12 of its edge connector.
- The Drive Select signal must also enable the Head Load line.
- The MPI drives' Side Select lines must always be logic high.

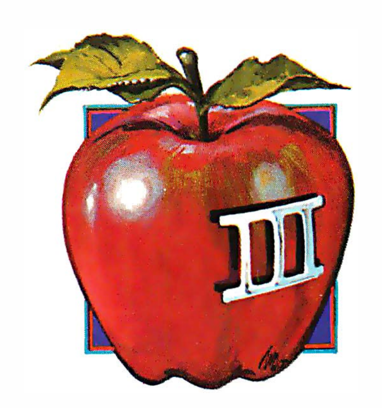
The above conditions can be achieved by placing two jumper connections across the following pins of the shunt socket on the MPI drives:

1 to 14 (Head Load connecting to Drive Select)
3 to 12 (Drive Select connecting with pin 12)

and cutting the trace on the MPI printed-circuit board leading to pin 34 of the edge connector (just above the contact), allowing this pin to stay in the high state.

Note that the termination-resistor pack (150-ohm pull-up resistors) should be left in the A drive only; *remove* this pack from the B drive but place a single 150-ohm resistor between pins 2 and 13 of this socket. This pulls the Side Select line up to the high state.

Kim B. Lignell
649 South Harvard Ave.
Addison, IL 60101 ■



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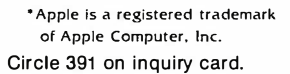
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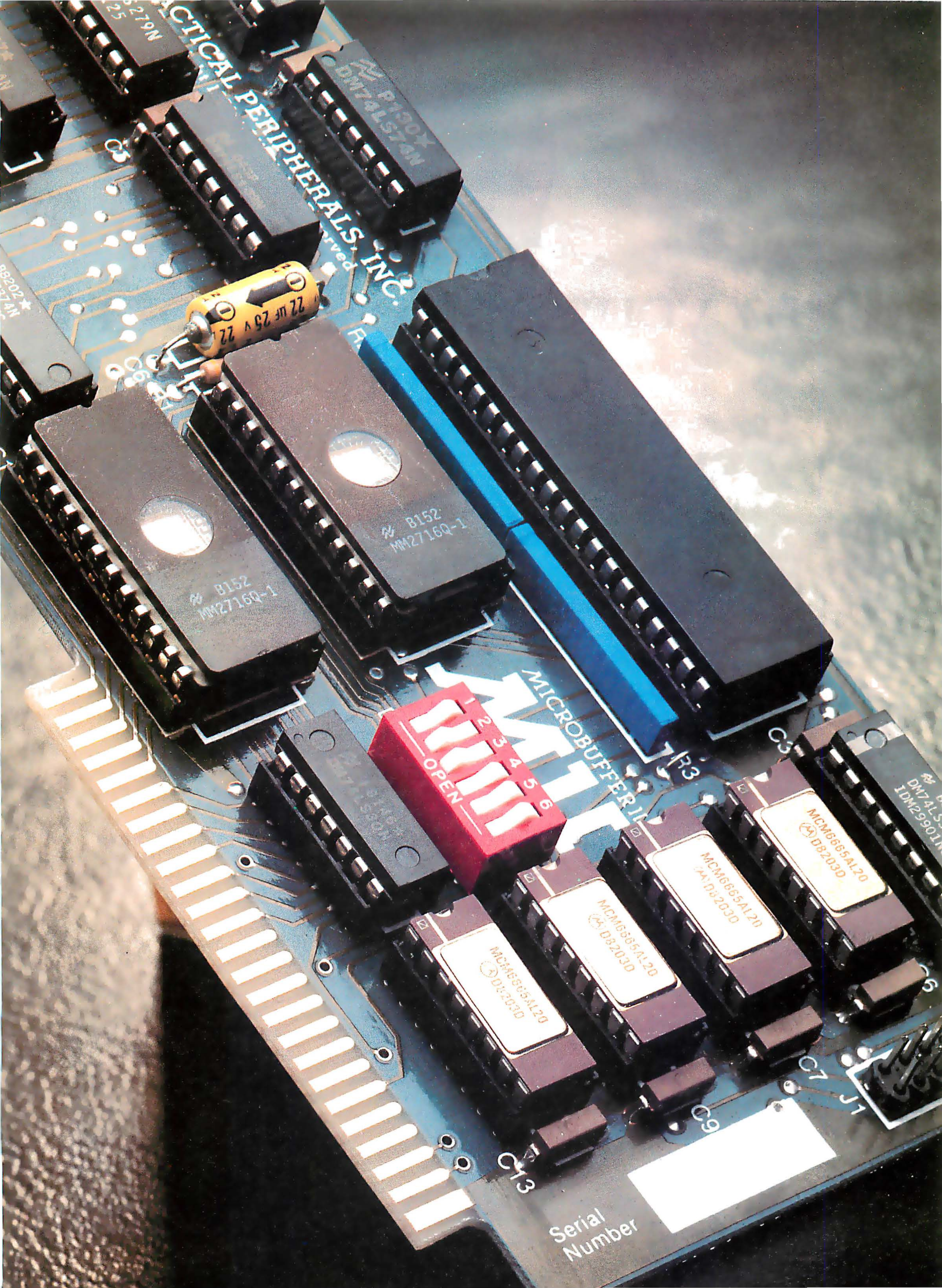




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BYTE Game Contest

Quinti-Maze

Robert Tsuk
17 Lexington Ave.
Plattsburgh, NY 12901

The Quinti-Maze game takes you on a three-dimensional adventure through a 5-by-5-by-5 cubic maze. The object of the game is to find your way through the rooms and out of the maze in as little time as possible.

The program is written in Applesoft BASIC for an Apple II with 32K bytes of memory and one disk drive. Although it's written in BASIC, Quinti-Maze is a fast game to play (see listing 1). But setting up the maze takes about 30 seconds (see photo 1). One room at a time appears on the screen, showing you four possible exits—one in each of the three visible walls and one in either the floor or ceiling.

Playing the Game

At the start of the game, you're asked if you want to see the instructions. If you don't, the screen then displays a view of one of the rooms, in high-resolution graphics, located somewhere in the maze. The direction in which you are facing is indicated at the bottom center of the screen.

You move around the maze by entering any of the following commands:

U—up	E—east
D—down	W—west
N—north	F—change facing direction
S—south	Q—quit

Every time you enter a command, you move to another room or get a different perspective of your location in the room. The rooms look nearly identical, except for the varying positions of the doors and holes in the floor or ceiling. As you move about the maze, the computer ticks off the seconds, keeping track of your total time. The elapsed time is displayed in the lower left-hand corner of the screen.

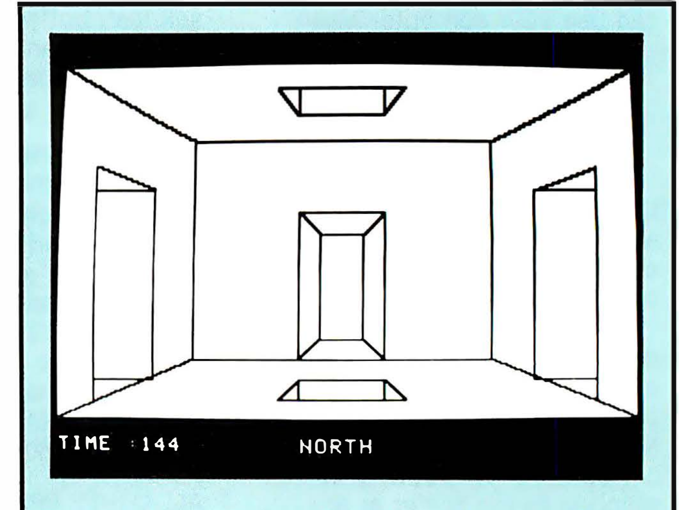


Photo 1: *View of one of the rooms in the maze. You can change the direction you are facing or move in any direction by entering one of the commands.*

When you enter the F command, to change your direction, the program asks that you enter the new direction.



If you enter the Q command, to stop the game, the program asks if you want to save the current maze. If you do, the program requests a name for the maze and then saves it on the disk. When you next play Quinti-Maze, the program asks if you want to start in a new maze or recall an old maze from the disk. If you want to recall an old maze, you enter the name of the maze. The program returns you to the same room and with the same cumulative time as when you last quit the game.

Strategy

The strategy for Quinti-Maze is fairly simple; be methodical. Because all the rooms in the maze look similar, you could wander around forever without finding the exit. My favorite method is to travel in one direction for as far as I can go, then I assume I'm at one of the outside walls and search there for an exit.

Conclusion

Quinti-Maze is a simple yet very playable game. Because it is written in BASIC you can easily modify the program to include your own special features. A denizen or two would add even more excitement to Quinti-Maze.■

The author has offered to make copies of his program available to BYTE readers for $5. Send a blank disk and a self-addressed stamped envelope to:

Robert Tsuk
17 Lexington Ave.
Plattsburgh, NY 12901

Listing 1: *Quinti-Maze, written in Applesoft BASIC, requires an Apple II with 32K bytes of memory and one disk drive.*

```
1  DATA  201,84,208,15,32,177,0,3
     2,248,230,138,72,32,183,0,20
     1,44,240,3,76,201,222,32,177
     ,0,32,248,230
2  FOR I = 768 TO 833: READ P: POKE
     I,P: NEXT I
3  DATA  104,134,3,134,1,133,0,17
     0,160,1,132,2,173,48,192,136
     ,208,4,198
4  DATA  1,240,7,202,208,246,166,
     0,208,239,165,3,133,1,198,2,
     208,241,96
5  POKE 1013,76: POKE 1014,0: POKE
     1015,3
10  TEXT : HOME
90  GOSUB 2000
100  DIM FC(5,7): DIM FC$(5)
105 FC$(1) = "NORTH":FC$(2) = "SO
     UTH":FC$(3) = "EAST":FC$(4) =
     "WEST"
110  FOR B = 1 TO 4: FOR I = 1 TO
     6: READ FC(B,I): NEXT : NEXT

115  GOTO 155
120  HPLOT 0,0 TO 279,0 TO 279,15
     9 TO 0,159 TO 0,0 TO 69,29 TO
     209,29 TO 209,129 TO 69,129 TO
     69,29: HPLOT 209,29 TO 279,0
     : HPLOT 209,129 TO 279,159: HPLOT
     69,129 TO 0,159: RETURN
125  RETURN
130  HPLOT 109,9 TO 169,9 TO 159,
     19 TO 119,19 TO 109,9: HPLOT
     119,19 TO 119,9: HPLOT 159,1
     9 TO 159,9: RETURN

135  HPLOT 119,139 TO 159,139 TO
     169,149 TO 109,149 TO 119,13
     9: HPLOT 119,139 TO 119,149:
      HPLOT 159,139 TO 159,149: RETURN

140  HPLOT 19,39 TO 49,49 TO 49,1
     39: HPLOT 19,149 TO 19,39: HPLOT
     19,139 TO 49,139: HPLOT 19,4
     9 TO 49,49: RETURN
145  HPLOT 119,59 TO 159,59 TO 15
     9,129 TO 119,129 TO 119,59 TO
     129,69 TO 149,69 TO 149,119 TO
     129,119 TO 129,69: HPLOT 149
     ,69 TO 159,59: HPLOT 149,119
      TO 159,129: HPLOT 129,119 TO
     119,129: RETURN
150  HPLOT 229,49 TO 259,39 TO 25
     9,149: HPLOT 229,139 TO 229,
     49: HPLOT 229,49 TO 259,49: HPLOT
     229,139 TO 259,139: RETURN
155  DIM S$(6,6)
160  INPUT "RESTART OLD MAZE ";Y$
     : IF  LEFT$ (Y$,1) = "Y" THEN
     1360
165  FOR A = 1 TO 5: FOR X = 1 TO
     5: FOR Y = 1 TO 5
167  & T10 * A + 10 * X + 10 * Y,
     10
```

Listing 1 continued on page 26

Listing 1 continued:

```
170  IF A < > 5 AND  RND (1) < .
     80 THEN S$(X,A) = S$(X,A) +
     "O": GOTO 180
175 S$(X,A) = S$(X,A) + "X"
180  IF  MID$ (S$(X,A - 1),(Y - 1
     ) * 6 + 1,1) = "O" THEN S$(X
     ,A) = S$(X,A) + "O": GOTO 19
     0
185 S$(X,A) = S$(X,A) + "X"
190  IF Y - 2 < 0 THEN 200
195  IF  MID$ (S$(X,A),(Y - 2) *
     6 + 4,1) = "O" THEN S$(X,A) =
     S$(X,A) + "O": GOTO 205
200 S$(X,A) = S$(X,A) + "X"
205  IF Y < > 5 AND  RND (1) < .
     8 THEN S$(X,A) = S$(X,A) + "
     O": GOTO 215
210 S$(X,A) = S$(X,A) + "X"
215  IF X < > 5 AND  RND (1) < .
     8 THEN S$(X,A) = S$(X,A) + "
     O": GOTO 225
220 S$(X,A) = S$(X,A) + "X"
225  IF  MID$ (S$(X - 1,A),(Y - 1
     ) * 6 + 5,1) = "O" THEN S$(X
     ,A) = S$(X,A) + "O": GOTO 23
     5
230 S$(X,A) = S$(X,A) + "X"
235  NEXT : NEXT : NEXT
240 X =  INT ( RND (1) * 3) + 2:Y
      =  INT ( RND (1) * 3) + 2:A
      =  INT ( RND (1) * 3) + 2
245 RD =  INT ( RND (1) * 6) + 1:
     ON RD GOTO 250,255,260,265,
     270,275
250 A = 5:P1$ =  LEFT$ (S$(X,A),(
     Y - 1) * 6):L = 29 -  LEN (P
     1$):P2$ =  RIGHT$ (S$(X,A),L
     ):S$(X,A) = P1$ + "O" + P2$:

     GOTO 280
255 A = 1:P1$ =  LEFT$ (S$(X,A),(
     Y - 1) * 6 + 1):L = 29 -  LEN
     (P1$):P2$ =  RIGHT$ (S$(X,A)
     ,L):S$(X,A) = P1$ + "O" + P2
     $: GOTO 280
260 Y = 5:P1$ =  LEFT$ (S$(X,A),(
     Y - 1) * 6 + 3):L = 29 -  LEN
     (P1$):P2$ =  RIGHT$ (S$(X,A)
     ,L):S$(X,A) = P1$ + "O" + P2
     $: GOTO 280
265 Y = 1:P1$ =  LEFT$ (S$(X,A),(
     Y - 1) * 6 + 2):L = 29 -  LEN
     (P1$):P2$ =  RIGHT$ (S$(X,A)
     ,L):S$(X,A) = P1$ + "O" + P2
     $: GOTO 280
270 X = 5:P1$ =  LEFT$ (S$(X,A),(
     Y - 1) * 6 + 4):L = 29 -  LEN
     (P1$):P2$ =  RIGHT$ (S$(X,A)
     ,L):S$(X,A) = P1$ + "O" + P2
     $: GOTO 280
275 X = 1:P1$ =  LEFT$ (S$(X,A),(
     Y - 1) * 6 + 5):L = 29 -  LEN
     (P1$):P2$ =  RIGHT$ (S$(X,A)
     ,L):S$(X,A) = P1$ + "O" + P2
     $: GOTO 280
280 SX = X:SY = Y:SA = A
```

Listing 1 continued on page 28


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Listing 1 continued:

```
290   VTAB 23: PRINT "HIT ANY KEY
      TO START"
300   IF  PEEK ( - 16384) < 127 THEN
      300
310   POKE  - 16368,00
1000  X =  INT ( RND (1) * 5) + 1:
      Y =  INT ( RND (1) * 5) + 1:
      A =  INT ( RND (1) * 5) + 1:
      FC = 1: GOTO 1220
1010   HOME : VTAB 22: HTAB 18: PRINT
      FC$(FC):A$ = "":D = 0: IF LS
       = 1 THEN  PRINT X,Y,A
1020   VTAB 22: PRINT "TIME :";T: FOR
      TIME = 1 TO 80
1025   IF  PEEK ( - 16384) > 127 THEN
      1030
1027   NEXT :T = T + 1: VTAB 22: PRINT
      "TIME :";T: GOTO 1020
1030   GET A$
1035   IF A$ = "*" THEN LS = 1
1040   IF A$ = "Q" THEN 1300
1050   IF A$ = "U" THEN D = 1
1060   IF A$ = "D" THEN D = 2
1070   IF A$ = "N" THEN D = 3
1080   IF A$ = "S" THEN D = 4
1090   IF A$ = "E" THEN D = 5
1100   IF A$ = "?" THEN 1290
1110   IF A$ = "W" THEN D = 6
1120   IF A$ = "F" THEN  GOTO 1280

1130   IF D = 0 THEN 1010
1135  T = T + 1
1140   IF  MID$ (S$(X,A),(Y - 1) *
       6 + D,1) <  > "O" THEN  PRINT
       CHR$ (7): GOTO 1010
1150   ON D GOTO 1160,1170,1180,11
      90,1200,1210
1160  A = A + 1: GOTO 1220
1170  A = A - 1: GOTO 1220
1180  Y = Y - 1: GOTO 1220
1190  Y = Y + 1: GOTO 1220
1200  X = X + 1: GOTO 1220
1210  X = X - 1: GOTO 1220
1220   IF X > 5 OR X < 1 OR Y > 5 OR
      Y < 1 OR A > 5 OR A < 1 THEN
       PRINT "YOU WIN": & T100,100
      : & T100,50: & T100,50: & T7
      5,66: & T100,66: & T75,66: &
      T60,255: GOTO 3000
1230   HGR : HCOLOR= 3: HPLOT 0,0:
       CALL 62454: HCOLOR= 0: GOSUB
      120
1240   FOR I = 1 TO 6: IF  MID$ (S
      $(X,A),(Y - 1) * 6 + I,1) =
      "X" THEN  NEXT : GOTO 1010
1250  R = FC(FC,I) + 1
1260   HCOLOR= 0: ON R GOSUB 125,1
      30,135,140,145,150
1270   NEXT : GOTO 1010
1280   INPUT "WHAT FACING 1-N 2-S
      3-E 4-W";FC: IF FC < 1 OR FC
       > 4 THEN 1280
1285   GOTO 1220
1290   INVERSE : HTAB 18: PRINT SX
      ;"  ";SY;"  ";SA: NORMAL : GOTO
      1220
```

Listing 1 continued on page 30



The most complete Pascal programming package is available for both 8 and 16-bit computers. Pascal/MT+ is the choice of professional software writers and hardware vendors. Pascal/MT+ is fast, versatile, and portable, plus it's easier to use than other Pascals. In fact, no other Pascal gives you the many programming conveniences of Pascal/MT+. Our superior native code compiler, 8087 support, advanced debugging tools, and ROM-able code make it perfect for every professional application.

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Tokyo 107, Japan
03-403-2120
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Pascal/MT+™

Listing 1 continued:

```
1300  PRINT "DO YOU WANT TO SAVE
     THIS MAZE": INPUT Y$: IF  LEFT$
     (Y$,1) <  > "Y" THEN  GOTO 3
     000
1310  INPUT "WHAT DO YOU WANT TO
     CALL IT ";N$
1320 D$ =  CHR$ (4)
1330  PRINT D$;"OPEN OLD MAZE/";N
     $: PRINT D$;"WRITE OLD MAZE/
     ";N$
1340  FOR A1 = 1 TO 5: FOR X1 = 1
      TO 5: PRINT S$(X1,A1): NEXT
     : NEXT : PRINT X: PRINT Y: PRINT
     A: PRINT T: PRINT FC
1350  PRINT D$;"CLOSE OLD MAZE/";
     N$: GOTO 3000
1360  INPUT "WHAT IS ITS NAME ";N
     $
1370 D$ =  CHR$ (4)
1380  PRINT D$;"OPEN OLD MAZE/";N
     $: PRINT D$;"READ OLD MAZE/"
     ;N$
1390  FOR A1 = 1 TO 5: FOR X1 = 1
      TO 5: INPUT S$(X1,A1): NEXT
     : NEXT : INPUT X: INPUT Y: INPUT
     A: INPUT T: INPUT FC
1400  PRINT D$;"CLOSE OLD MAZE/";
     N$: GOTO 1220
2000  VTAB 12: HTAB 18: INVERSE :
      PRINT "MAZE": NORMAL : VTAB
     22: INPUT "DO YOU WANT INSTR
     UCTIONS ";Y$: IF  LEFT$ (Y$,
     1) <  > "Y" THEN  RETURN
2005  PR# 1
2010  HOME : PRINT "THE OBJECT OF
      MAZE IS TO FIND YOUR WAY": PRINT
     : PRINT "OUT OF A 5X5X5 CUBI
     C MAZE. IN ONE OF THE": PRINT
     "ROOMS THERE IS AN EXIT OUT
      OF THE MAZE."
2020  PRINT : PRINT "YOU MUST TRY
      TO FIND IT IN AS FEW TURNS
     ": PRINT "AS POSSIBLE. THE C
     OMMANDS ARE  :"
2030  PRINT : HTAB 6: INVERSE : PRINT
     "U";: NORMAL : PRINT "-UP";:
      HTAB 17: INVERSE : PRINT "S
     ";: NORMAL : PRINT "-SOUTH"
2040  PRINT : HTAB 6: INVERSE : PRINT
     "D";: NORMAL : PRINT "-DOWN"
     ;: HTAB 17: INVERSE : PRINT
     "E";: NORMAL : PRINT "-EAST"

2050  PRINT : HTAB 6: INVERSE : PRINT
     "N";: NORMAL : PRINT "-NORTH
     ";: HTAB 17: INVERSE : PRINT
     "W";: NORMAL : PRINT "-WEST"

2060  PRINT : HTAB 6: INVERSE : PRINT
     "Q";: NORMAL : PRINT "-QUIT"
     ;: HTAB 17: INVERSE : PRINT
     "F";: NORMAL : PRINT "-CHANG
     E FACING"
2070  VTAB 23: PRINT "HIT ";: INVERSE
     : PRINT "SPACE";: NORMAL : PRINT
     " FOR MORE"
2080  IF  PEEK ( - 16384) < 127 THEN
     2080
2090  POKE  - 16368,0: HOME : INVERSE
     : PRINT "F";: NORMAL : PRINT
     " WILL COME BACK WITH A QUES
     TION AS TO": PRINT : PRINT "
     WHICH FACING YOU WISH.HIT ON
     LY ONE KEY": PRINT : PRINT "
     AND ";: INVERSE : PRINT "RET
     URN": NORMAL
2100  PRINT : PRINT "PLEASE WAIT
     WHILE IT SETS UP THE MAZE": PRINT
     : PRINT : RETURN
3000  TEXT : HOME : VTAB 5: HTAB
     12: PRINT "CONGRATULATIONS !
     "
3010  PRINT : PRINT  TAB( 7)"YOU
     HAVE FINISHED THE MAZE IN ":
     PRINT  TAB( 7)T;" SECONDS"
3030  INPUT "DO YOU WANT TO PLAY
     AGAIN ? ";Y$
3040  IF  LEFT$ (Y$,1) = "Y" THEN
      RUN
9999  NORMAL
10000  DATA     1,2,4,0,5,3,1,2,0
     ,4,3,5,1,2,3,5,4,0,1,2,5,3,0
     ,4
```

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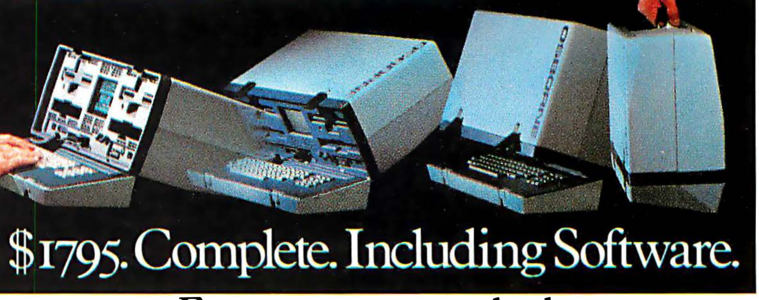
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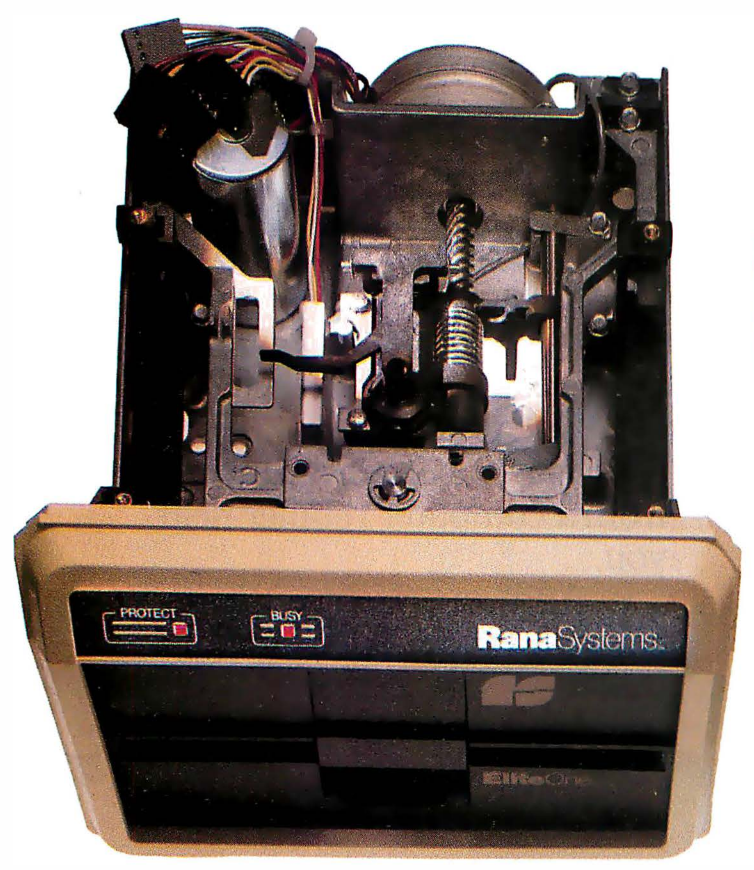
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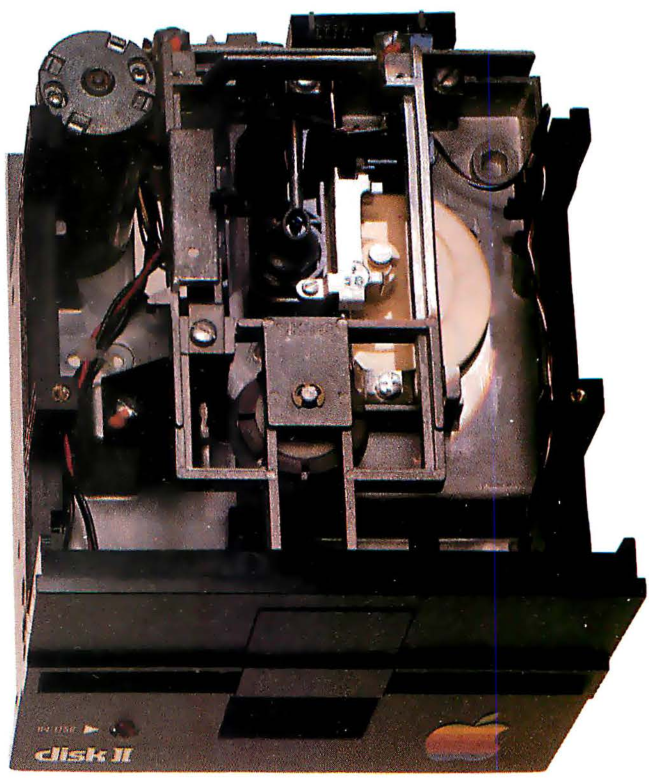
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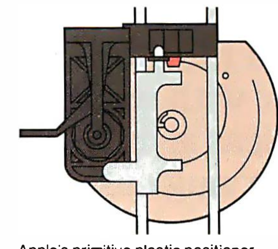




The problem with Apple's disk drive stems from the core.

There are a lot of good reasons why dealers all over America aren't recommending Apple's disk drive. And one of the main reasons is Rana Systems' new Elite Series of Apple II compatible disk drives.

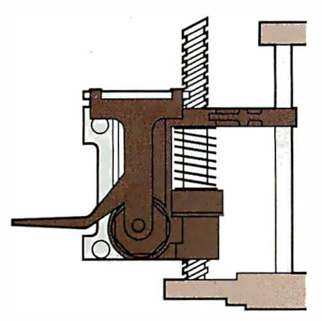
It's easy to see why Apple® has been having some major slipped disk problems. Just look at their antiquated head positioner. It's plastic. Just like a toy. That's why it can take multiple passes to get the information needed. And why the information on your disk can appear obscured and unreadable. If Apple's positioner doesn't accurately center the head over your data tracks, it's no bargain at any price.



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More juice on Apple's inferiority.

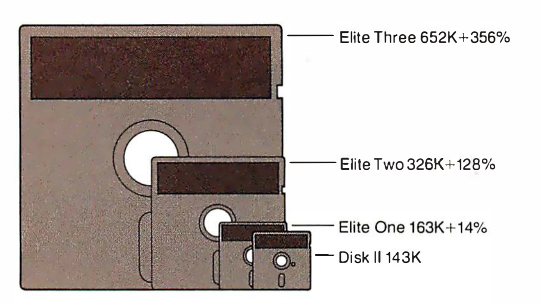
There's another big problem Apple has chosen to ignore. The irritating scratching noise that occurs when it is searching for information. Rana, on the other hand, has built the Elite Series to be virtually noiseless.

And more importantly, Rana has an advanced write protect feature which makes it impossible to lose your information. A simple touch on the front panel's membrane switch gives you failsafe control. Apple of course only has a notch or tab, which gives you only minimal protection.

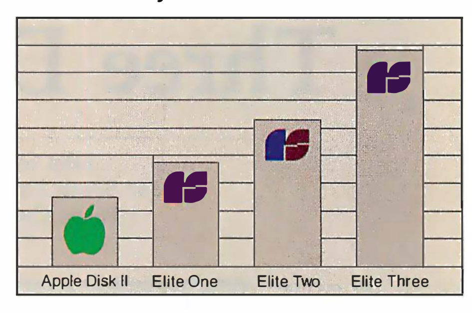
With the superior Elite controller card, you can control up to four floppy disks using only one slot. With Apple's you can only use two. Of course, you can still plug into Apple's controller card, but down the line you'll want to switch to Rana's and save yourself a slot.

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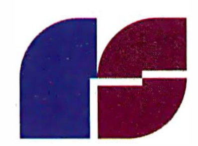


The real beauty of it isn't the beauty of it.

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Circle 405 on inquiry card.

BYTE Game Contest

Three Dee Tee

John Stuart
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Three Dee Tee is a computer game for two players, which runs on the Radio Shack TRS-80 Color Computer. It is loosely based on the Rubik's cube game and Tic Tac Toe. The object of the game is to color three cubes in a line either vertically, horizontally, or diagonally. The computer keeps track of every winning combination and displays a box score for each player.

When you start the program, the computer draws two cubes. One cube is larger than the other and represents the front view. The smaller cube shows the back view of the cube as if viewed in a mirror. After the program generates these two cubes, it draws 9 smaller subcubes on each face. There are 6 faces with 9 subcubes each for a total of 54 subcubes.

Next, the computer colors a subcube for player A. It then starts moving the color cursor around the cube in an orderly fashion. It may take you some time to get oriented to the pattern of movement. Observe that one, two, or three faces can be colored for each subcube, depending on its position. If some of the faces are on the back of the cube, the smaller cube will show the color. Thus, a subcube can be colored on the front view, the back view, or both.

The cursor starts at the subcube 1 corner of the cube (see figure 1).

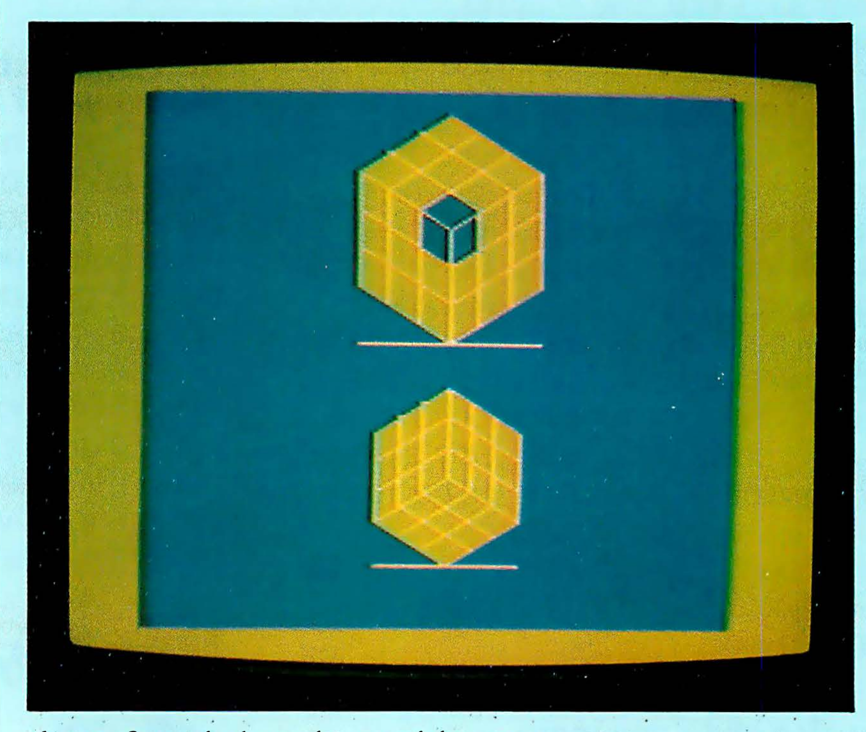
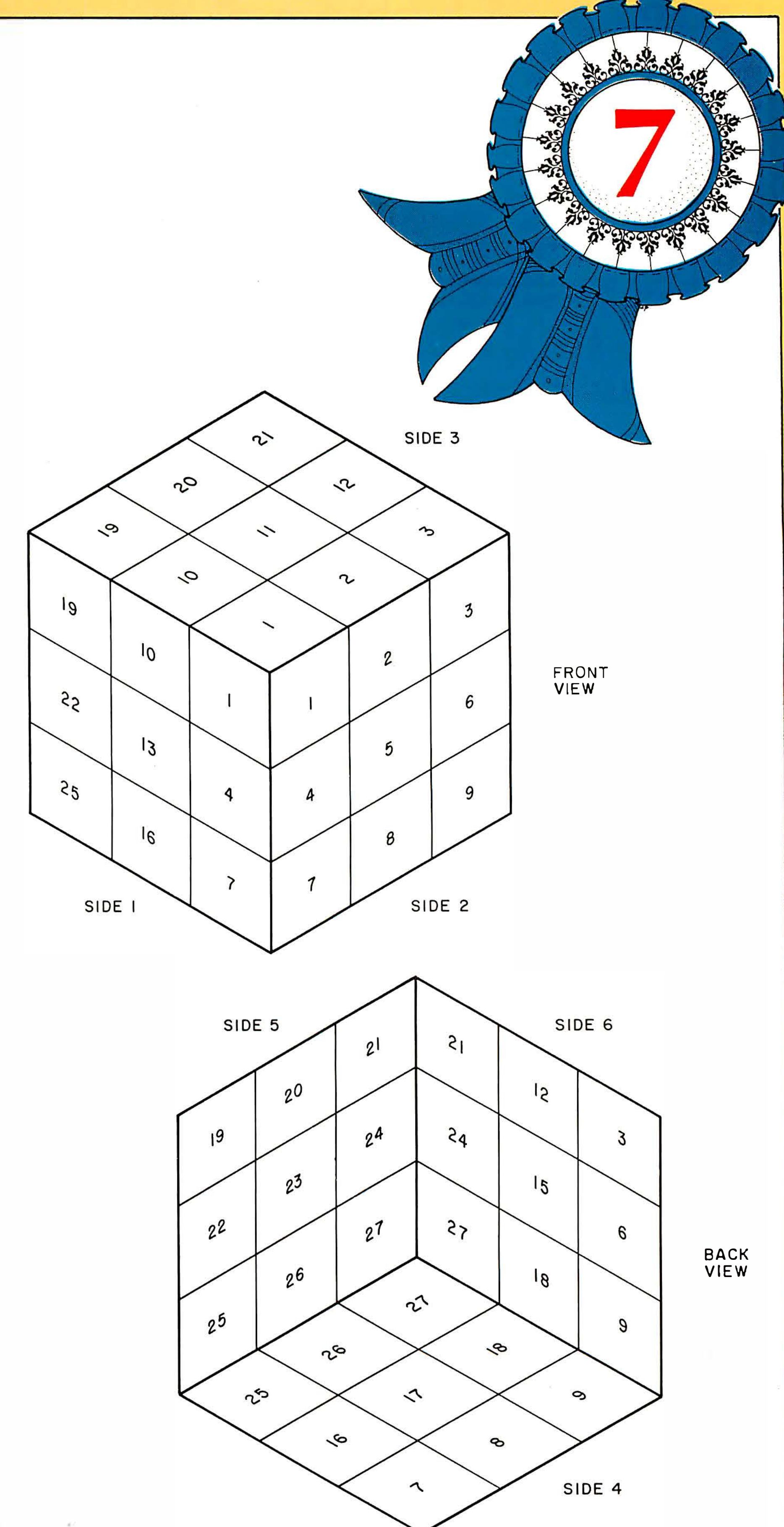


Photo 1: *Screen display at the start of the game.*

Photo 1 shows the view at the start of the game. The cursor moves along each row of the cube, coloring each of 27 subcubes in turn; the center one is skipped, so it takes 26 moves to traverse the entire cube. When player A presses any key, the subcube is permanently colored, and player B's color then starts moving around the cube. If a straight line of three subcubes together in a player's color are made, then a point is recorded in



the player's column. The winner is the player who has the highest box score when all subcubes are colored.

Program Design

Initially, I intended to rotate one cube on the screen and let the players move the cursor using joysticks, but several problems forced me to abandon this approach. The mathematics involved in rotating the cube in order to give a three-dimensional effect got very complicated for someone who had managed to avoid trigonometry in school. Even when I developed a BASIC program that would crudely represent an object rotating in space, it was too slow to give the appearance of a smooth rotation. Therefore, I decided to take the approach of displaying the front and back of a cube.

I organized the program to do the following major tasks:

- draw the cube views
- move the cursor around the subcubes for each player
- build a win table of all winning combinations
- check each player's move against the win table, and display the score

The flowchart explains the logic of the program routines that accomplish these tasks (see figure 2).

Figure 1: *Numbering scheme used by the program to determine the position of the cursor.*

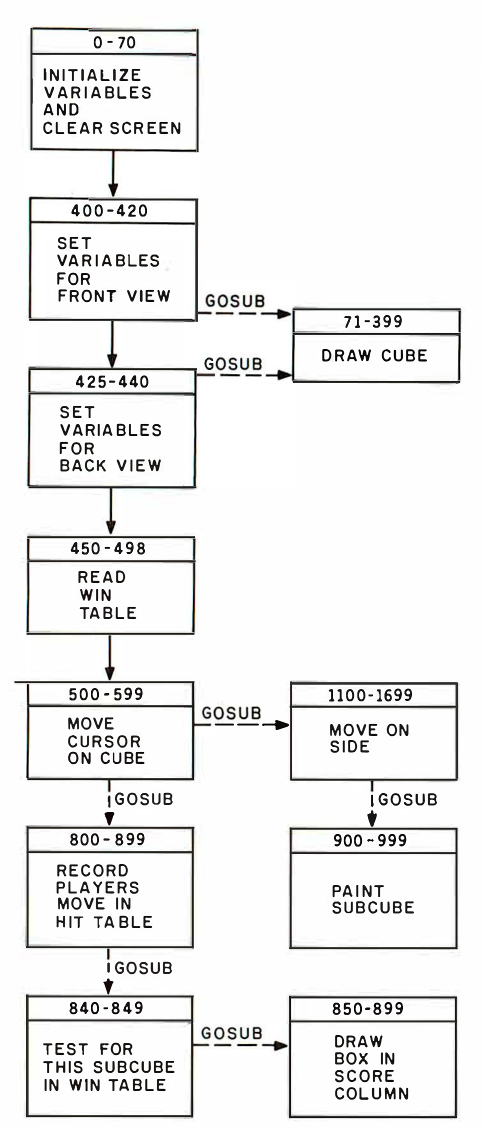


Figure 2: *Flowchart of the Three Dee Tee program.*

Drawing the Cubes

The subroutine at line 71 is used to draw the cubes (see listing 1). This subroutine is written so that it can be changed to draw different size cubes at different locations on the screen. The instructions at lines 400-420 set the size and location for the front view of the cube, and lines 425-440 change the size and location for the back view of the cube.

First, the subroutine at line 71 computes the variables used to draw the cube using the size and location set by the calling routine. See figure 3 and table 1 for an explanation of these variables. The instructions at lines 100-399 then use these variables in Line commands to draw the different

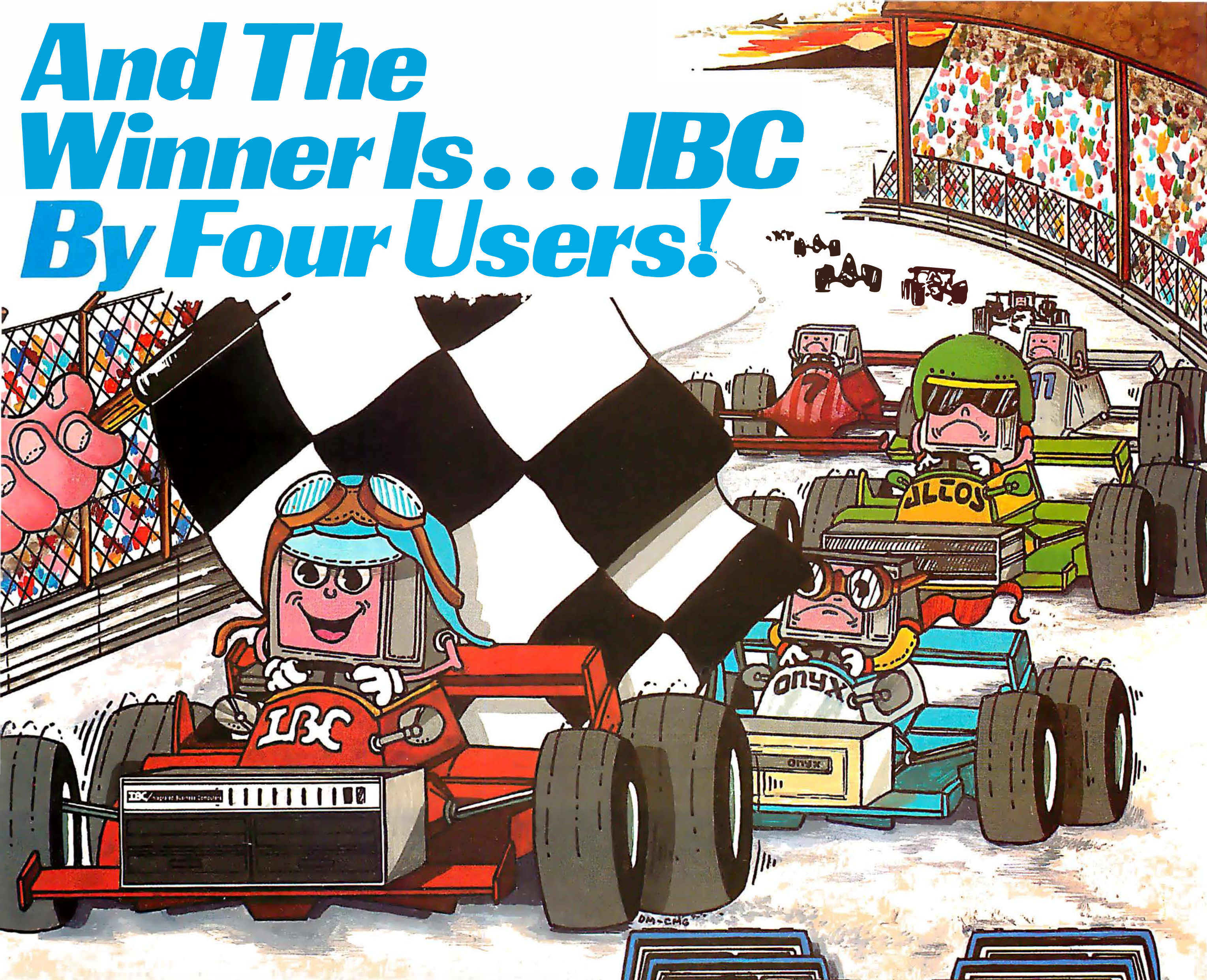
Text continued on page 45

Listing 1: *Three Dee Tee runs on the TRS-80 Color Computer and requires 16K bytes of memory.*

```
1 REM 3DT GAME COPYRIGHT
2 REM 1981 JOHN C STUART
5 CLEAR 100
10 PCLEAR 4
20 PMODE 3,1
30 B=3:F=2
31 P=1
32 AS=180:BS=180
33 PA=3:PB=4
34 PN=PA
40 COLOR F,B
50 SCREEN 1,0
51 PCLS B
54 DIM WN(48,3)
55 DIM CC(27)
56 FOR BN=1 TO 27
58 CC(BN)=1
60 NEXT BN
62 BN=0
69 GOTO 400
70 REM COMP CUBE VARIABLES
71 X1=X/3
72 X2=X*2/3
81 LC=H-2*X
82 MC=H
83 RC=H+2*X
84 V1=V-2*X
85 V2=V-X
86 V3=V
87 V4=V+X
88 V5=V+2*X
100 REM DRAW CUBE
110 LINE(MC,V3)-(MC,V5),PSET
120  LINE(MC,V5)-(RC,V4),PSET
125 LINE(RC,V4)-(RC,V2),PSET
130 LINE(RC,V2)-(MC,V3),PSET
135 LINE(MC,V3)-(LC,V2),PSET
140 LINE(LC,V2)-(LC,V4),PSET
145 LINE(LC,V4)-(MC,V5),PSET
150 LINE(LC,V2)-(MC,V1),PSET
155 LINE(MC,V1)-(RC,V2),PSET
200 PAINT(H-D,V),P,F
205 PAINT(H+D,V),P,F
210 PAINT(H,V-D),P,F
300 LINE(LC,V+X1)-(MC,V+2*X2),PSET
305 LINE(LC,V-X1)-(MC,V+X2),PSET
310 LINE(RC,V+X1)-(MC,V+2*X2),PSET
315 LINE(RC,V-X1)-(MC,V+X2),PSET
320 LINE(LC+X2,V-X2)-(LC+X2,V+X+X1),PSET
325 LINE(MC-X2,V-X1)-(MC-X2,V+X+X2),PSET
330 LINE(MC+X2,V-X1)-(MC+X2,V+X+X2),PSET
335 LINE(RC-X2,V-X2)-(RC-X2,V+X+X1),PSET
340 LINE(LC+X2,V-X2)-(MC+X2,V-X-X2),PSET
345 LINE(MC-X2,V-X1)-(RC-X2,V-X-X1),PSET
350 LINE(LC+X2,V-X-X1)-(MC+X2,V-X1),PSET
```

Listing 1 continued on page 38

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Listing 1 continued:

```
355 LINE(MC-X2,V-X-X2)-(RC-X2,V-X2),PSET
375 LINE(H-2*ABS(X),V+2*ABS(X))-(H+2*ABS(X),V+2*ABS(X)),PSET
399 RETURN
400 REM DRAW BOXES
401 FH=128
402 BH=128
403 FV=48
404 BV=136
405 D=2
406 FX=20
407 BX=-16
409 X=FX
410 H=FH
415 V=FV
419 REM DRAW FR0NT VIEW
420 GOSUB 71
425 V=BV
430 H=BH
435 X=BX
436 D=-2
439 REM DRAW BACK VIEW
440 GOSUB 71
450 BX=BX*-1
460 FOR WC=1 TO 48
462 FOR CN =1 TO 3
465 READ WN(WC,CN)
```

Listing 1 continued on page 40

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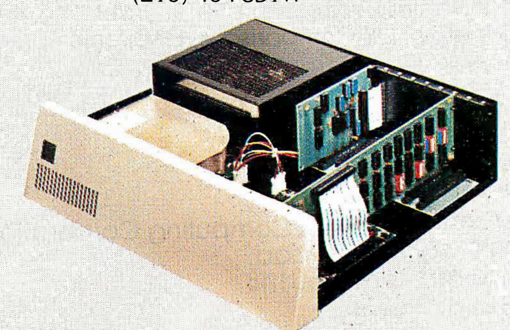
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Circle 453 on inquiry card.

Listing 1 continued:

```
470 NEXT CN
472 NEXT WC
473 N=0
474 REM SIDE 2
475 DATA 1,2,3,4,5,6,7,8,9
477 DATA 1,4,7,2,5,8,3,6,9
479 DATA 1,5,9,3,5,7
480 REM SIDE 1
482 DATA 1,10,19,4,13,22,7,16,25,1,4,7,10,13,16,19,22,25,1,13,25,7,13,19
484 REM SIDE 3
486 DATA 1,2,3,10,11,12,19,20,21,1,10,19,2,11,20,3,12,21,1,11,21,3,11,19
488 REM SIDE 4
490 DATA 7,8,9,16,17,18,25,26,27,7,16,25,8,17,26,9,18,27,7,17,27,9,17,25
492 REM SIDE 5
494 DATA 19,20,21,22,23,24,25,26,27,19,22,25,20,23,26,21,24,27,19,23,27
495 DATA 21,23,25
496 REM SIDE 6
498 DATA 3,12,21,6,15,24,9,18,27,3,6,9,12,15,18,21,24,27,3,15,27,9,15,21
499 REM MOVE CURSOR
500 FOR L1=1 TO 3
510 FOR L2=1 TO 3
515 FOR L3=1 TO 3
516 TIMER =0
517 BN=BN+1:IF BN=28 THEN BN=1
519 IF CC(BN)>1 THEN GOTO 590
520 REM TEST FOR ACTIVE SIDE
```

Listing 1 continued on page 42

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Circle 244 on inquiry card.

Listing 1 continued:

```
523 IF L3=1 THEN GOSUB 1100
525 IF L1 = 1 THEN GOSUB 1200
530 IF L2=1 THEN GOSUB 1300
540 IF L2=3 THEN GOSUB 1400
545IF L1=3 THEN GOSUB 1500
550 IF L3=3 THEN GOSUB 1600
555 IF BN=14 THEN 590
559 REM DELAY LOOP
560 IF TIMER < 60 THEN 560
561 K$=INKEY$
562 IF K$ <> "" THEN 800
569 REM CLEAR SUBCUBE COLOR
570 FOR M=1 TO N
575 PAINT(SH(M),SV(M)),P,F
580 NEXT M
585 N=0
590 NEXT L3
591 NEXT L2
592 NEXT L1
599 GOTO 500
800 REM RECORD MOVE
803 PLAY "L25;A;D;A;D;"
805 CC(BN)=PN
809 REM FIND BN IN TABLE
810FOR WC=1 TO 48
812 FOR CN=1 TO 3
814 IF WN(WC,CN)=BN THEN GOSUB 840
818 NEXT CN
820 NEXT WC
830 K$=""
835 IF PN=PA THEN PN=PB ELSE PN=PA
838 N=0
839 GOTO 590
840 HT=0
841 REM FIND 3 TOGETHER
842 FOR LT=1 TO 3
844 TM=WN(WC,LT)
846 IF CC(TM)=PN THEN HT=HT+1
847 NEXT LT
848 IF HT=3 THEN GOSUB 850
849 RETURN
850 IF PN=PB THEN 870
851 REM RECORD WIN PLAYER A
852 COLOR PA,F
854 LINE(192,AS)-(208,AS-4),PRESET,B
855 PAINT(200,AS-2),PA,F
860 AS=AS-4
865 PLAY"O2;L2;A"
869 RETURN
870 COLOR PB,F
873 REM RECORD WIN PLAYER B
875 LINE (220,BS)-(236,BS-4),PRESET,B
877 PAINT(224,BS-2),PB,F
880 BS=BS-4
885 PLAY"O4;L2;C"
890 RETURN
899 REM PAINT SUBCUBE
900 HP=SH-LM*(L1-1)+RM*(L3-1)
910 HV=SV-LU*(L1-1)-RU*(L3-1)+DM*(L2-1)
```

Listing 1 continued on page 44

CompuStar™

CompuStar's 255-User Controller
shown with a 96MB Disk Storage System.

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When we unveiled our CompuStar™ multi-user terminal system just over a year ago, we thought we had created the most powerful, lowest-priced multi-user computer we would ever manufacture. We were wrong. Today, we've made our best even better!

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Circle 245 on inquiry card.

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Listing 1 continued:

```
920 PAINT(HP,HV),PN,F
930 N=N+1
940 SH(N)=HP
950 SV(N)=HV
990 RETURN
1000 REM SET VARIABLES EACH SIDE
1100 BW=2*FX/3
1110 SH=FH-.5*BW
1120 LM=BW:RM=0:RU=0:DM=BW
1130 SV=FV+.5*BW
1140 LU=.5*BW
1150 GOSUB 900
1190 RETURN
1200 BW=2*FX/3
1210 SH=FH+.5*BW
1220 LM=0:RM=BW:LU=0:DM=BW
1230 RU=.5*BW
1240 SV=FV+.5*BW
1280 GOSUB 900
1290 RETURN
1300 BW=2*FX/3:SH=FH
1310 LM=BW:RM=BW
1320 SV=FV-.5*BW
1330 LU=.5*BW:RU=.5*BW:DM=0
1380 GOSUB 900
1390 RETURN
1400 BW=2*BX/3
1410 SH=BH:LM=BW:RM=BW
1420 SV=BV+2.5*BW
1430 LU=.5*BW:RU=.5*BW:DM=0
1480 GOSUB 900
1490 RETURN
1500 BW=2*BX/3
1510 SH=BH-2.5*BW
1520 LM=0:RM=BW
1530 SV=BV-1.5*BW
1540 LU=0:RU=.5*BW:DM=BW
1580 GOSUB 900
1590 RETURN
1600 BW=2*BX/3
1610 SH=BH+2.5*BW
1620 LM=BW:RM=0
1630 SV=BV-1.5*BW
1640 LU=.5*BW:RU=0:DM=BW
1680 GOSUB 900
1690 RETURN
```



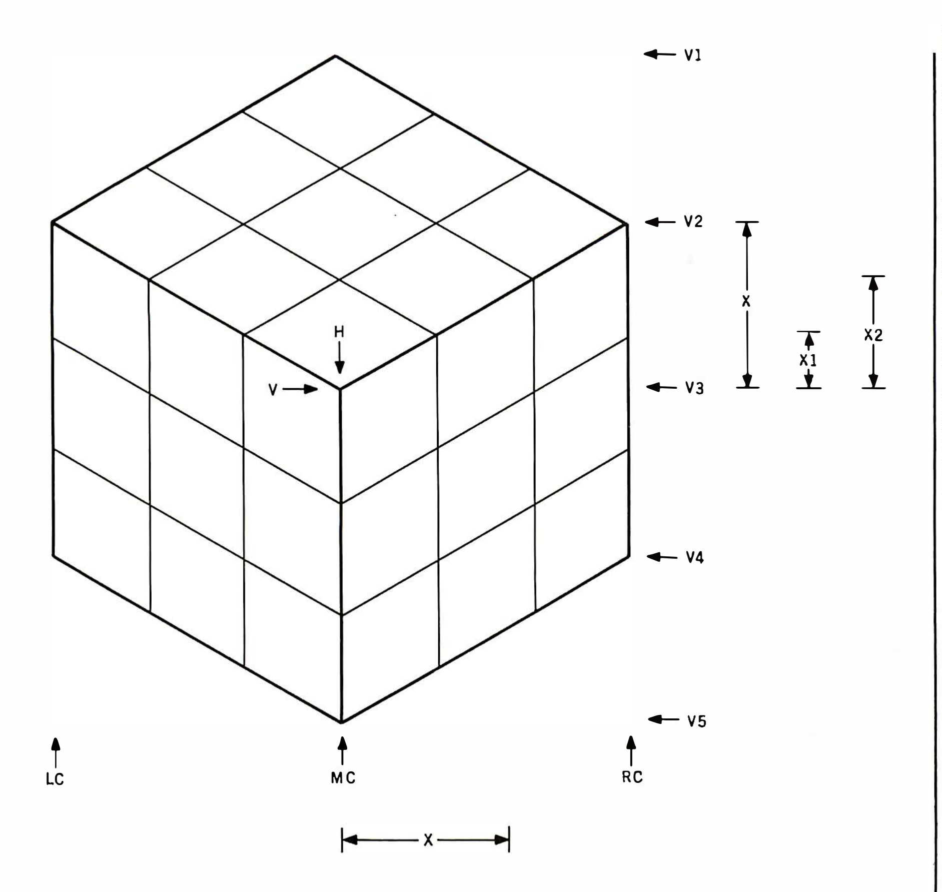



Figure 3: *Location of the variables used to draw the initial view of the cube.*

Variable	Description
X	one-half the difference between the center of the cube and the outer limits of the cube in a horizontal or vertical direction
H	the horizontal coordinate of the cube center
V	the vertical coordinate of the cube center
LC	the leftmost corner of the cube
MC	the middle corner of the cube
RC	the rightmost corner of the cube
V1	the top of the cube
V2	V1 – X
V3	V1 – 2X
V4	V1 – 3X
V5	the bottom of the cube

Table 1: *Description of the variables used to draw the cube.*

Text continued from page 36:

lines required for the cube. The Paint command is used to color the subcubes.

The subroutine that draws the cube is written so that the back view of the cube is drawn in the mirror image of the front cube, putting the face that is closest to the viewer on the bottom of the cube instead of the top. This is achieved by making *BX* a negative number in line 407, which reverses all drawing directions.

The preceding change in the program illustrates the symmetry involved in drawing a geometric figure with a computer. When I finished the program, I felt that drawing each line using a command was a crude way to program this figure. I suspect a better programmer would be able to reduce the number of statements considerably by using FOR. . .NEXT loops.

Moving the Cursor

When I started writing the program, I thought that moving the cursor among the subcubes would be simple, but it turned out to be the hardest task. The scheme I finally

Subcube Number *N*	Vertical Slice *L1*	Horizontal Row *L2*	Vertical Column *L3*
1	1	1	1
2	1	1	2
3	1	1	3
4	1	2	1
5	1	2	2
6	1	2	3
7	1	3	1
8	1	3	2
9	1	3	3
10	2	1	1
11	2	1	2
12	2	1	3
13	2	2	1
14	2	2	2
15	2	2	3
16	2	3	1
17	2	3	2
18	2	3	3
19	3	1	1
20	3	1	2
21	3	1	3
22	3	2	1
23	3	2	2
24	3	2	3
25	3	3	1
26	3	3	2
27	3	3	3

Table 2: *Values of variables L1, L2, and L3 used to determine the position of the cursor.*

settled on was to move the cursor using three FOR. . .NEXT loops at lines 500-599. The outer loop (L1) represents one of three vertical slices of the cube, the next loop (L2 in line 510) represents the horizontal rows on each slice, and the inner loop (L3 in line 515) represents the vertical columns on each slice. Table 2 shows the contents of the three variables that are used to control the loops for each subcube, and figure 1 shows the subcube numbers.

An inspection of table 2 and figure 1 reveals that the position of the cursor on a side can be determined by the value of one of the variables L1 to L3. For example, whenever one of the top subcubes (side 3) is addressed, L2 is a 1. Line 530 tests L2 for a 1 and executes the subroutine that paints the top side of the cube.

The subroutines at lines 1100, 1200, 1300, 1400, 1500, and 1600 that handle moving the cursor on each side use another subroutine at line 900 to paint the player's color. Before it executes a GOSUB 900, the calling subroutine first determines the contents of the variables that will be used by line 900 to determine the location of the subcube to paint. The variable *HP* contains the horizontal position, and variable *HV* contains the vertical position that the Paint command uses. The amount of movement is determined by the distance each subcube is from subcube 1 when L1, L2, or L3 is 1.

For example, when the cursor is on subcube 1 then L1, L2, and L3 are all 1, and subroutines at lines 1100, 1200, and 1300 will be executed to paint subcube 1 on three sides. When the subcube changes to 2, L3 becomes 2, while L2 and L1 stay at 1, and subroutines at lines 1200 and 1300 are executed. These two subroutines store values in variables *RM* and *RV* that equal the number of dots needed to move to subcube 2 from subcube 1. When the statements at lines 900 and 910 are executed, variables *HP* and *HV* are adjusted by the values in variables *RM* and *RU*, and subcube 2 is painted. This procedure is used for each subcube. If you work out the values in the subroutines using table

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Circle 412 on inquiry card.

Variable Name	Side 1 1100	Side 2 1200	Side 3 1300	Side 4 1400	Side 5 1500	Side 6 1600
	Side and Subroutine Line Numbers					
BW	2*FX/3	2*FX/3	2*FX/3	2*BX/3	2*BX/3	2*BX/3
SH	FH − .5*BW	FH + .5*BW	FH	BH	BH − 2.5*BW	BH + 2.5*BW
LM	BW	0	BW	BW	0	BW
RM	0	BW	BW	BW	BW	0
SV	FB + .5*BW	FV + 5*BW	FV − .5*BW	BV + 2.5*BW	BV − 1.5*BW	BV − 1.5*BW
LU	.5*BW	0	.5*BW	.5*BW	0	.5*BW
RU	0	.5*BW	.5*BW	.5*BW	.5*BW	0
DM	BW	BW	0	0	BW	BW

Table 3: *Formulas used to compute the distance to move the cursor to a particular subcube from subcube 1.*

3, you will see that the table does give the location of the subcube on each side. It also shows the formulas used to compute these values for each side.

Keeping Score

A player scores a point when he gets three subcubes together in his color in a horizontal, vertical, or diagonal direction. Each subcube can have as many as three faces; therefore, it is possible for a subcube to be involved in as many as nine winning combinations. In fact, you can score as many as 9 points on three different faces in one move. Photo 2 shows the game after one player has scored 6 points by marking subcube 1.

The program keeps score first by building an array in memory for all the possible winning combinations using lines 450-499. There are 6 sides with 8 winning combinations on a side, or a total of 48 winning combinations. The winning numbers are read from memory in groups of 3 and stored in array WN, which is dimensioned in line 54.

Each time a player makes a move, the subroutine in line 800 is executed. Array CC keeps track of the player who has colored each subcube. Array WN is then searched to see if the subcube that was just colored is in a winning combination. If the subcube number is found, the three subcubes are checked to see if they are all the same color. If they are, then the player is given credit for a score in the subroutine in line 850. The entire table of winning combinations is searched in this way, and all winning combinations are identified and displayed. Photo 3 shows the game after all subcubes have been colored.

Future Changes

This program was written so that it could be easily changed. The colors, location of the cubes, and sizes of the cubes can all be changed by changing variables in the beginning of the program. The cursor can be made to move faster or slower by changing the constant in line 560.

This version is a straightforward game without much variety. I am

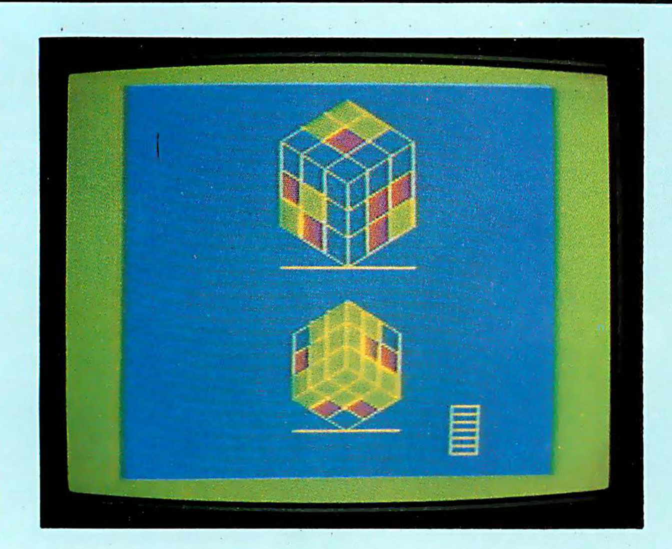


Photo 2: *One player has scored 6 points by coloring the seven subcubes on the forward-facing cube.*

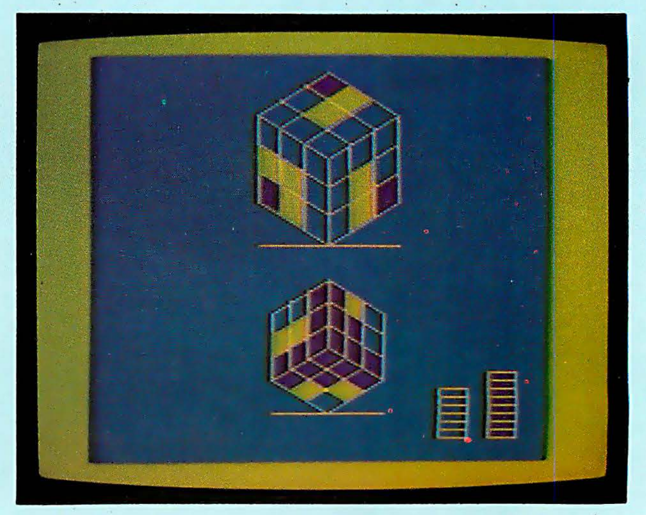
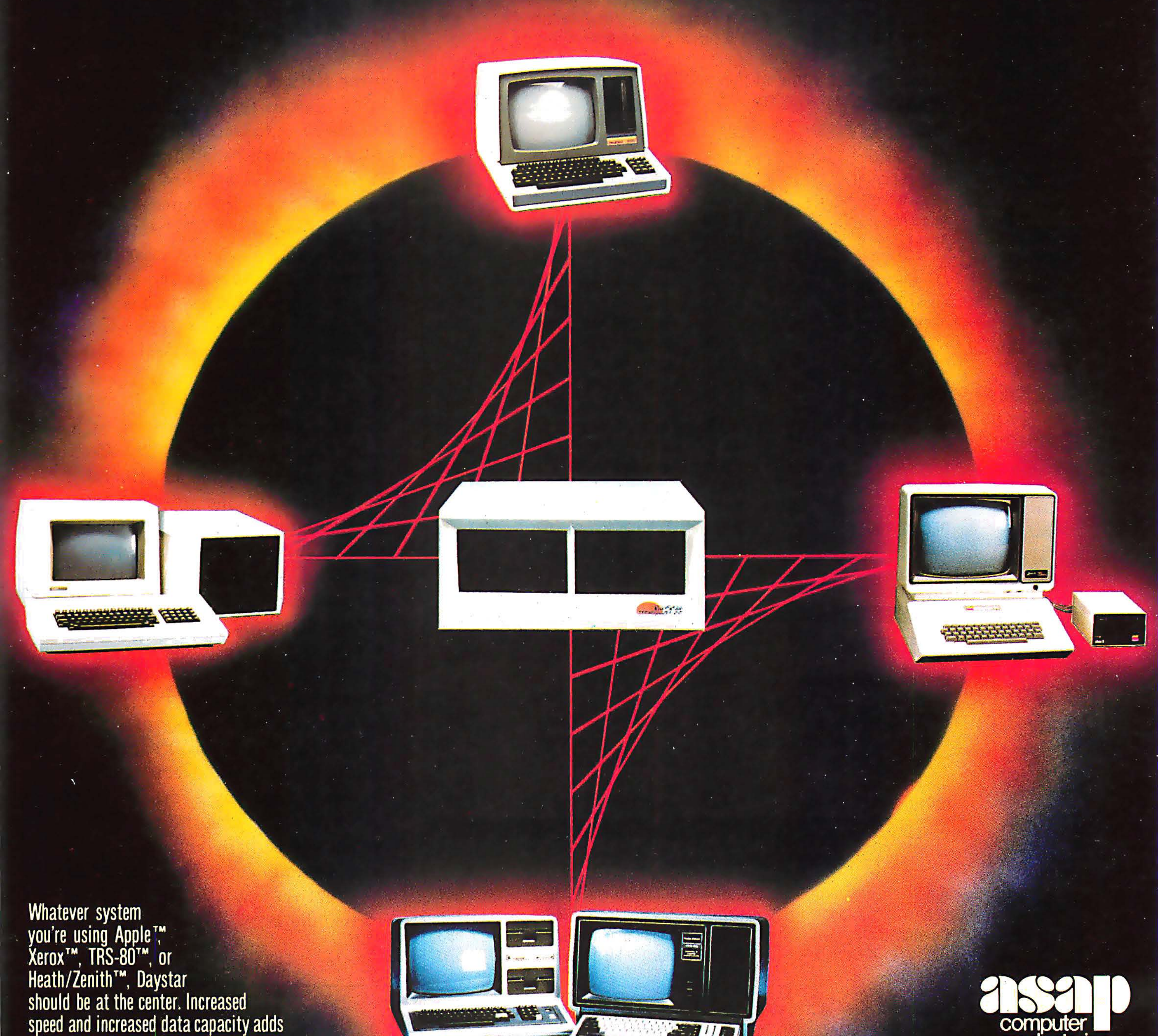


Photo 3: *Screen display showing all the subcubes colored. The scores for each player are shown in the lower-right corner.*

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working on another version now that will make the game more competitive. This can be done by moving two cursors at once, random movements, changing speeds, etc. You should be able to design your own game version with some thought.

Some Reflections

My reasons for doing this project initially were to learn the Color Computer's graphics capabilities, win the BYTE game contest, and do something with my idle computer. Somewhere along the way I thought it might be educational to other people and so decided to write this article.

I did learn a lot about the Color Computer graphics, and what I learned reinforced my opinion that the Color Computer is a powerful computer for the money. In many ways the graphics are as powerful as those for the IBM Personal Computer, which costs considerably more. Some of the graphics commands are limited, but you can usually find a way to accomplish your objectives. Doing graphics in BASIC will probably be too slow for many projects requiring fast movement of objects on the screen, and these projects will have to be done with assembly-language programs or machine-language subroutines.

All in all, I am glad I engaged in this effort. I hope that you can learn something from my efforts that will save you some time on a computer project, or perhaps you will simply enjoy playing Three Dee Tee. If so, the effort will have been worthwhile. ■

Improved Version Available

The author will make copies of an improved version of his program available to BYTE readers. Send a blank cassette tape, a self-addressed stamped envelope, and a check or money order for $8 to:

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The Epson QX-10/Valdocs System

Gregg Williams
Senior Editor

These are wonderful days for people who need computers. Microcomputers that do more and more are becoming available—and, paradoxically, they are becoming *less* expensive. The only trouble is that, between the time you order a unit and it is delivered, something better is announced (but you *know* it will be six months to a year before the new unit will be available).

As the saying goes, I've got bad news and good news. The bad news is that, yes, another wonderful computer is about to come out—from Epson, the company that has captured about 75 percent of the printer market. The good news is that the unit is supposed to be available by this Christmas. On the basis of Epson's track record, I believe they'll do it.

BYTE was one of the few companies to be given a private showing this past summer of the Epson QX-10, a computer for less than $3000 that may well be the first of a new breed of anybody-can-use-it "appliance" computers. Chris Rutkowski, president of Rising Star Enterprises (a consulting firm that works closely with Epson), showed me the QX-10, along with a preliminary version of an extended word processor called Valdocs and an enhanced keyboard design called HASCI, both designed by his company. As you'll be able to tell from this article, I found them both very interesting.

QX-10 Hardware

For its retail price of less than $3000, the QX-10 (see photo 1) gives you a great deal for your money. It contains a Z80 microprocessor running at 4 megahertz (MHz), 128K bytes of memory (expandable to 256K bytes), two direct memory access (DMA) controllers, one free serial port (a second one is used by the keyboard), a Centronics-compatible parallel port, six clock-timers, 2K bytes of battery-powered complementary metal-oxide semiconductor (CMOS) memory (to hold certain information even when the computer is turned off), a CMOS clock/calendar, and a light-pen interface. The unit also contains two thinline 5¼-inch floppy-disk drives, each double-sided and double-density, with 40 tracks per inch; each drive holds 320K bytes. The video display, based on the NEC 7220 graphics chip, includes a 32-MHz medium-persistence video monitor and 128K bytes of dedicated video memory (shown as the bottom board in photo 2). The video display will work in either a 25-line by 80-character text mode or a 640- by 400-pixel graphics mode. The QX-10 comes with one of two detachable keyboards—standard-layout or HASCI—more on that later. Finally, the QX-10 has internal space for up to five peripheral cards like those used by the Apple, Corvus, and IBM microcomputers.

QX-10 Configurations

The QX-10 will be sold in two configurations. The first includes (at the time of this writing) the QX-10 as described above, the standard-layout keyboard, the CP/M operating system, Microsoft BASIC, and STOIC (a fast, extensible FORTH-like language). This version is a standard CP/M-based microcomputer for those of us who are comfortable with microcomputers as we know them today.

However, the QX-10 was really designed for the average consumer, who *isn't* comfortable with microcomputers as we know them today. With the software included in this package, the QX-10 becomes (as Ep-



Photo 1: *The Epson QX-10/Valdocs system.*

son puts it) a *symbol processor* that anyone can use. This configuration of the QX-10 includes the hardware as described above, the HASCI keyboard, the Valdocs software, TP/M (a CP/M equivalent with its own enhancements), Microsoft BASIC, and STOIC. (CP/M may be offered in place of TP/M, but the configuration will probably be very close to the one listed above.)

The Epson Philosophy

Although Epson will certainly sell you the CP/M version of the QX-10, it is far more interested in selling you the unit it really designed—hardware and software designed *in conjunction with each other* to offer both high performance and ease of use. In addition to being a highly integrated word-processing/computer system that offers as much usable processing power as almost any existing microcomputer, the QX-10/Valdocs system is designed to be used without confusion by people with minimal technical knowledge. We've certainly heard that claim before, but Epson has delivered on this promise in a way and to an extent that *no* microcomputer manufacturer has done.

The Valdocs (short for "valuable documents") system described here is designed to manipulate what Epson sees as the four types of symbols that people use: letters, numbers, graphics, and time. The HASCI keyboard (scheduled to be described next month by Chris Rutkowski in his article "An Introduction to the Human Applications Standard Computer Interface") is shown in photo 3. It is designed with a set of function keys that relate directly to the most common operations people perform on symbols. In addition, these keys are designed to be sufficient to drive any future symbol-manipulating software—that way, the keyboard layout won't change even when more sophisticated software is developed. Table 1 gives a brief description of the HASCI keyboard function keys.

Another aspect of the Epson philosophy is its commitment to ensure that all the parts of a system work together. (What's amazing is that the microcomputer industry has survived while blatantly ignoring this philosophy.) In the QX-10 (with or without Valdocs), the computer, its software, and its peripherals are meant to use each other's capabilities to the fullest. This goes hand in hand with Epson's vision of the dot-matrix printer as the universal standard for printing. Epson has designed a line of printers that act identically and are capable of printing both bit-mapped graphics and text in varying degrees of quality (draft-, correspondence-, and—with some future printer—letter-quality printing).

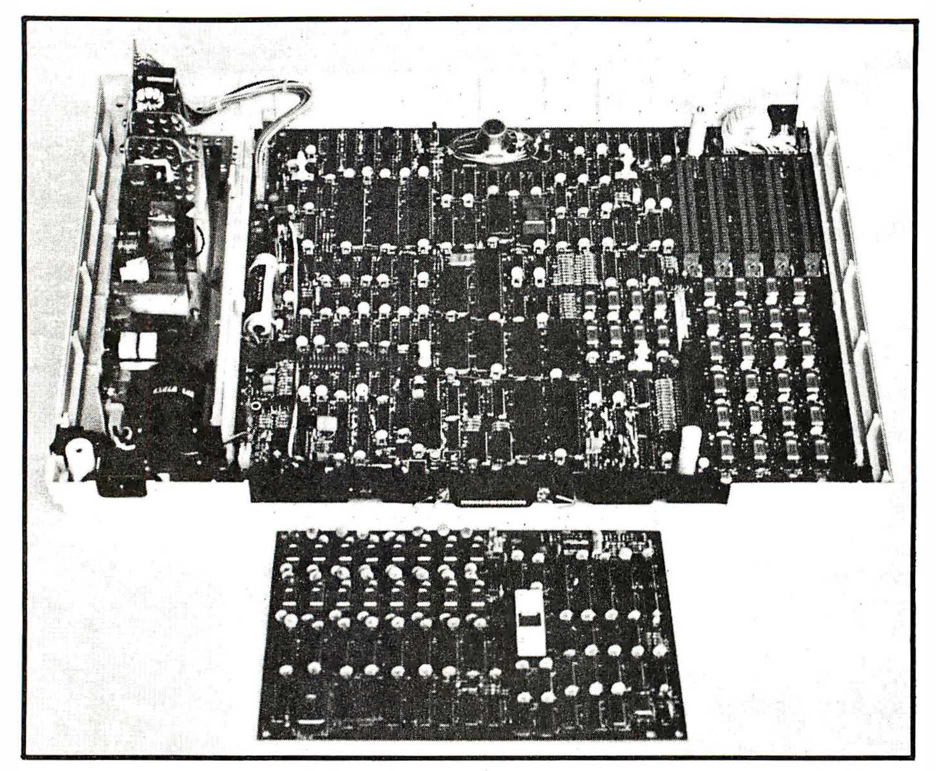


Photo 2: *Inside the Epson QX-10. The top unit is the motherboard of the QX-10; the rear of the unit is closest to the camera. The connectors in the upper right corner are the five slots for peripheral cards. The smaller board (below the motherboard) contains the 128K bytes of video-display memory; this card fits on top of the motherboard in the assembled unit.*

Valdocs

Epson wants the average person to be able to buy a QX-10/Valdocs system in a department store, plug it in, turn it on, and be able to type in a letter without having to read more than the unpacking instructions. Based on my inspection of a preliminary version of the Valdocs software, I believe that this is a realistic view of the system. Although I can't do a full review of the software based on the short amount of time I spent with the system, I do want to point out several unique features of the QX-10/Valdocs combination.

Help is available at any time through the HASCI keyboard Help key. An extensive text file of instructions is on the Valdocs system disk and can be read by pressing the Help key. This key gives you a menu of subjects that might be of interest (based on what you were doing when you pressed Help), as well as access to the entire Help file via user-entered keywords. Of course, the QX-10 returns to wherever you were before the Help key was pressed.

The Valdocs symbol processor can manipulate any of the four types of symbols at any time. Text can be entered at any time just as you would in any conventional word processor. The Calc key turns the system into a basic 4-function calculator. Graphics can be created via the Draw key. The Sched (schedule) key gives you access to a computer-kept appointment book, a built-in clock/timer/alarm, and an event scheduler; all these can be accessed without disturbing the file being edited.

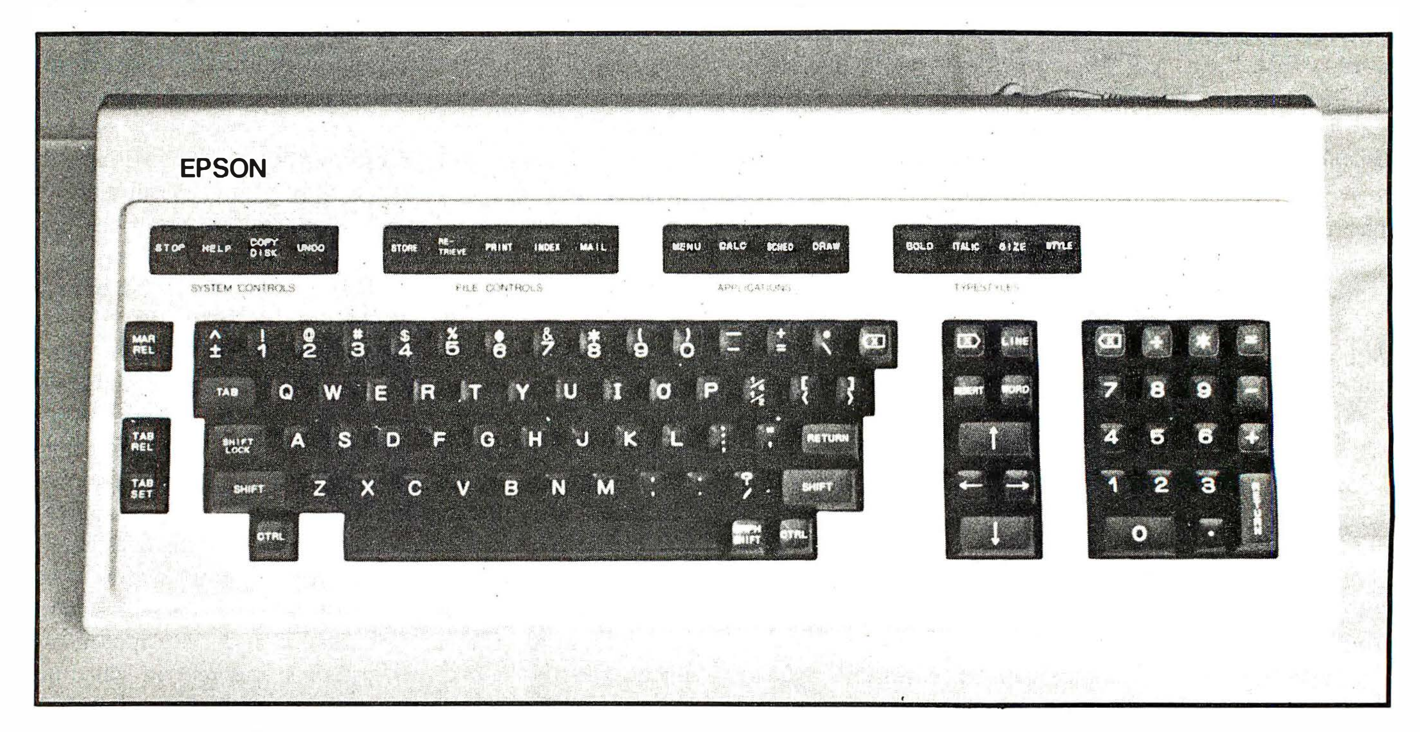


Photo 3: *The HASCI keyboard for the Epson QX-10/Valdocs system.*

The operation of all keys is as intuitive as possible. For example, when you use any of the type-font keys (Bold, Italic, Size, or Style), the video text image changes to reflect the use of those keys. When you hit the Italic key, all your subsequent typing appears on the screen as italics until you hit the key again to turn italics off. Also, keys like left-arrow, right-arrow, and Delete do their respective functions to words and lines (instead of individual characters) when used with the Word and Line keys.

It is impossible to make any major destructive change to your file without having the change explained to you and being asked to confirm it. In addition, the Undo key allows you to recover from the last major change made to the file.

The Valdocs system supports telecommunications and electronic mail in a way that is transparent to the user (through the Mail key, of course). You can be connected to the remote user by either a modem-telephone combination or a local network (probably the Corvus Omninet). Valdocs includes software that allows you to send and receive mail and access remote bulletin boards and databases.

The Valdocs file system is one example of the kind of levelheaded philosophy that is embodied everywhere in the Valdocs symbol processor. When you store a file, you give it a name of up to eight words—for example, "Letter, 8/13/82, to Bob Jackson; new rate schedule." When you hit the Index key, you can get a listing of all your files in one of several ways—sequentially, alphabetically, or by match of a given word to any keyword in any file. Using the last method of indexing, I could get a listing of all documents that are letters, all documents done on 8/13/82, or all documents that refer to a person named Bob. In addition, all documents are chosen by menu selection (so you don't have to type in a long file name). The utter sanity of this in comparison to file names like L081382.LTR is astounding.

One interesting technical note: to interactively create such a sophisticated word processor with the given time constraints, the Valdocs programmers used the STOIC language (a public-domain variant of FORTH created at the Biomedical Engineering Center of the Massachusetts Institute of Technology and Harvard University) to program the Valdocs symbol processor. It is a testament to the power of STOIC (and other threaded languages) that it was used to create a project of this scale.

New Products

Given the enhancements being planned, it may be that Valdocs is not so much a product as it is a design that Epson will always be improving. Epson plans to have version 2.0 of the Valdocs software available by mid-1983 (updates will be supplied at cost to owners of the QX-10/Valdocs system). Plans are under way for a color interface board and an Omninet interface board (for local networking). Epson is also considering such enhancements as higher-resolution graphics and additional graphics-oriented peripherals, as well as a portable version of Valdocs and perhaps a 16-bit system.

System Controls
- Stop—pauses whatever is occurring at the moment, letting you either resume or abort the operation.
- Help—lets you select and read parts of the disk-based Help file.
- Copy disk—lets you make a copy of a given floppy disk.
- Undo—undoes the last major destructive action.

File Controls
- Store—lets you save what you are working on to disk.
- Retrieve—lets you retrieve a file from disk.
- Print—lets you print a file.
- Index—allows you to see what files are on a floppy disk.
- Mail—allows you to send or receive a file electronically.

Applications
- Menu—gives you access to miscellaneous functions.
- Calc—gives you a 4-function calculator.
- Sched—gives you access to the scheduling functions of Valdocs.
- Draw—lets you draw graphics on the video display.

Typestyles
- Bold—toggles typeface between boldface and normal type.
- Italics—toggles typeface between italics and normal type.
- Size—lets you change the size of the type currently being used.
- Style—lets you change the typeface of the type currently being used.

Table 1: *A brief description of the function keys on the top row of the HASCI keyboard.*

One enhancement to the QX-10/Valdocs system that Chris Rutkowski did describe is the Valdocs FPL (Forms Processing Language). This is an additional software package that would give the user access to a spreadsheet package, a forms generator that would generate records from keyboard input, and a report generator that would create reports based on a database of records. As usual with ideas from Rising Star, the Valdocs FPL package is actually more than it seems—the spreadsheet and the form into which data is typed are actually the same thing, and a record of data can automatically be created from the spreadsheet. This is a new concept that combines spreadsheet forecasting, online data entry, and database management. It sounds exciting and I am looking forward to seeing it at work.

Final Thoughts

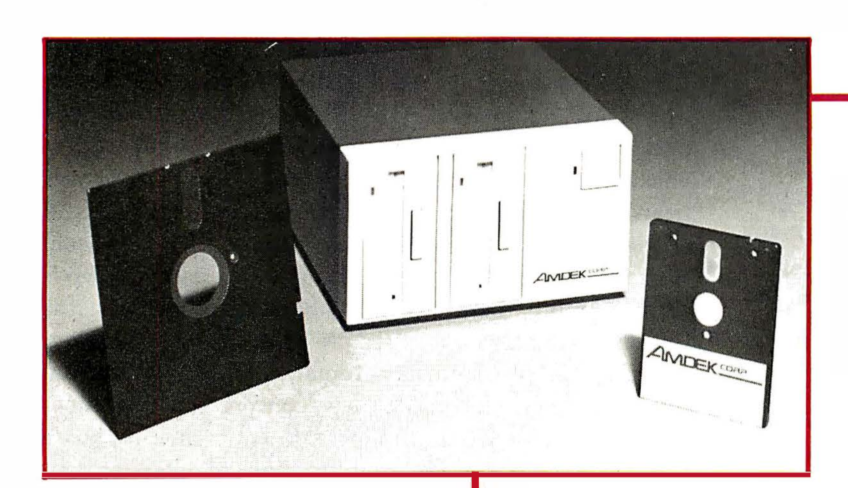
From what I have seen, Epson has created an enhanced personal word-processing system that *can* be (and is more likely to be) used by the person with minimal technical knowledge. Almost every microcomputer company claims that its product can be used by anybody, but many people (even those with technical knowledge) still have trouble getting started in personal computing. As microcomputers become more powerful, easier to use, and less expensive, the claim that "anyone can use it" will become true in a fuller and fuller sense, making previous claims seem naive and hollow. Still, the Epson QX-10/Valdocs system may become the first microcomputer that "really" fulfills that claim. BYTE will report to you again when the final unit becomes available. ■

NCC Report

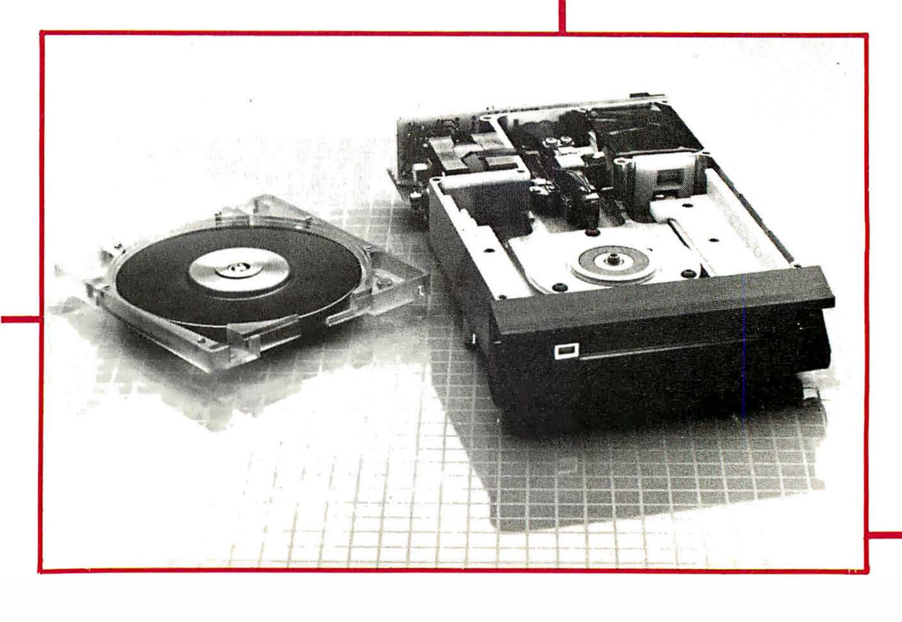
by Chris Morgan

Sensory overload.

How else do you describe the world's biggest computer exposition? It was the National Computer Conference, held this June in Houston, Texas, and it drew a crowd of nearly 100,000.



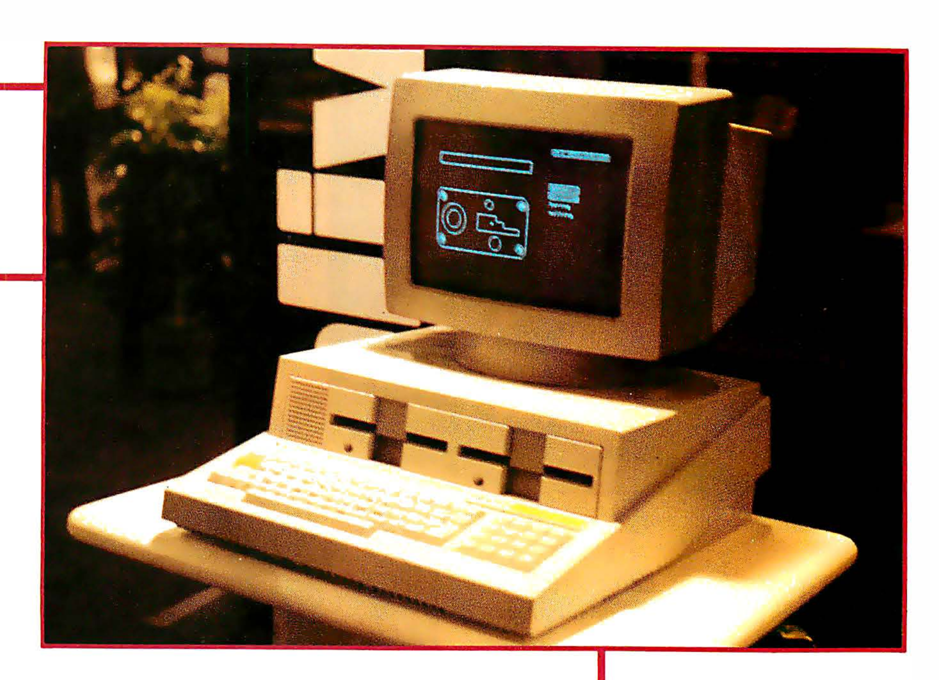
The new Hitachi miniature floppy-disk system in a version to be marketed by the Amdek Corp. The floppy-disk cartridge, shown at right, is slightly more than 3 inches wide. Compare it to the standard 5¼-inch floppy disk, shown at left.



The new Syquest miniature Winchester disk drive with removable media cartridge. Each cartridge holds 6.38 megabytes, unformatted. The unit is expected to sell for $750 in single-user quantities within the year. The cartridges will sell for about $35 each.

Photos by Gregg Williams, senior editor, and Richard Shuford, special projects editor.

Olivetti's new M 20 microcomputer.





The Commodore series B microcomputer.

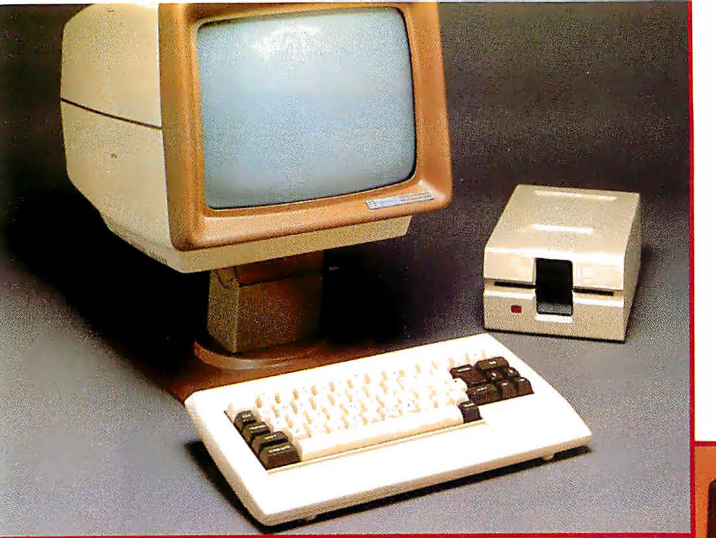
I've been attending the NCC for five years, and until this year microcomputers stayed in the background, playing a secondary role to mainframe computers. But this year the microcomputers came into their own, reflecting **Business Week's** recent projected figures showing microcomputers accounting for up to over 40 percent of the total computer market by 1985. A case in point, Apple's booth was the same size as IBM's, and it was attracting just as many visitors. Microcomputers have become indigenous to the NCC. Nearly as indigenous are the sore feet that come from trying to see several football fields' worth of booths in four short days.

The big question is, were there many surprises? No. And of equal importance, were there any signs of the beginnings of important trends? Yes.

Of surprises there were few; no bombshells on the order of last summer's unveiling of the IBM Personal Computer. Instead, the microcomputer software and hardware companies appeared to be carefully consolidating their positions, strengthening their distributorships, carefully evolving their product lines, and paying more attention to the needs of their customers. It was, in a sense, a much needed lull in the furious storm of research-and-development work, the fruits of which we'll see next year and beyond. Still, there was plenty to see this year.

Mass Storage

Suddenly, the miniature floppy-disk drive is upon us. Announce-



Cromemco's new C-10 computer system.

Visicorp's new Visicalc Advanced Version.

ments of new drives came from a trio of Japanese companies—Matsushita (Panasonic division), Hitachi, and Maxell—who are all pushing one format. As well, Canon announced its plans for a different, noncompatible format. This news follows on the heels of Sony's miniature 3-inch drive, which is already in production. Amdek Corporation, an American company, announced it is adopting the Matsushita design for its new miniature floppy-disk drive. All three noncompatible formats have miniature cassettes to hold the floppy medium, and they have double-density unformatted capacities of 80K bytes for the Canon, 437.5K bytes for the Sony, and 500K bytes for the Matsushita. Each standard miniature floppy disk calls for a cartridge 4 by 4 inches or smaller and less than 0.5 inch thick. Sinclair has also announced a miniature drive for its new Spectrum computer.

One of the most exciting announcements at the show was from Syquest. It's a 3.9-inch Winchester disk drive with removable media. Each cartridge holds 6.38 megabytes, unformatted. The surprise is its selling price: about $750 in single-user quantities within the year! This does not include the controller. Even so, inexpensive controllers are now available, making this a very attractive design. The entire unit fits in the space of a standard 5¼-inch floppy-disk drive. (It's actually shallower, with a vertical dimension of 1.625 inches.) The cartridges will sell for about $35 each. The secret to the low price: clever use of plated-media technology. We'll be reporting on this new technology in an upcoming issue.

Tandon Corporation announced a slim-line 5¼-inch floppy-disk drive for $50 (for quantities in the thousands of course), for the mechanical parts only. The company will provide customers with schematics and drawings to build their own electronics if they wish. It's an encouraging sign that prices will soon be dropping in the mass-storage market.

New Processors

Intel announced two new important integrated circuits: the 80186 and the 80286. Picture an 8086 with faster clock speed, some new instructions, and the equivalent of 20 auxiliary chips all on one VLSI (very large-scale integration) package for a single-user price (ultimately) of $35, and you have the 80186. It's the closest thing yet to a complete computer on a chip. The 80286 chip extends the idea of the 80186 to include built-in memory management and protection and a virtual address space of 1 gigabyte.

Systems

Olivetti introduced its new computer, the M 20, with a Z8001 processor, a 5-slot expansion bus, space for two 5¼-inch floppy-disk drives, and up to 128K bytes of memory. It's one of the more handsome units we saw at the conference, true to Olivetti's style. The operating system is Olivetti's own, called PCOS, and the machine will support Microsoft BASIC 5.2.

Commodore announced several new machines. The BX256 is a 16-bit, multiprocessor computer with 256K bytes of RAM (random-access read/write memory), extendable externally to 640K bytes, two processors (a 6509 and an 8088 for CP/M-86), an 80-column black-and-white video monitor, and a detachable keyboard. A three-voice music

synthesizer is also included, which uses the new 6581 microprocessor chip. An optional plug-in Z80 board is also available. Price is $2995. The business-oriented B128 offers features similar to the BX256's.

Another computer, the P128A, has 128K bytes of RAM, a 40-column by 25-line 16-color display, and a high-resolution 300- by 200-pixel display. It connects directly to either a video monitor or a color television set and sells for $995. An optional Z80 board for use with CP/M is also available.

The Commodore 64 offers 64K bytes of RAM, color graphics, and music synthesis for $595. A Z80 board can be added to run CP/M programs. The screen is 40 columns wide by 25 lines down, and the processor is the new 6510, which is similar to the 6502 with additional I/O (input/output) lines. Commodore gets the prize for the wildest styling of any computers we saw at the show.

Cromemco's new $1785 C-10 is a complete hardware/software system featuring a 4-MHz (megahertz) Z80A, 64K bytes of RAM, a 12-inch 80-character by 25-line display, double-sided double-density 5¼-inch floppy-disk drive, detachable keyboard, CP/M-compatible operating system, structured BASIC, a word processor, and a spreadsheet program.

Son of Visicalc

Visicorp announced the long-awaited successor to Visicalc. It's called Visicalc Advanced Version. For $400 you get a souped-up version of the most popular software package in the field. Many of the best features found in competing spreadsheet programs have been incorporated into Visicalc Advanced Version. As well, it has greatly expanded help files to aid the computer novice.

Its new features include protected cells to prevent accidental loss or change of information, hidden cells to protect sensitive information, a new tab feature to guide users from one space to the next, more formatting flexibility, variable column widths, keystroke memory to repeat frequently used commands, and more. Visicalc Advanced Version is compatible with the original Visicalc, which will still be sold for those who prefer it. Dan Fylstra, chairman of Visicorp, said that one of his goals in creating Visicalc Advanced Version was to make the program more of a "black box" for nontechnically oriented users so that they won't be distracted by unnecessary information. To that end, much of the instruction manual has been incorporated into the program's help files.



NEC's new APC (Advanced Personal Computer) executing a color-based spreadsheet program.

Software Trends

I saw the beginnings of two trends being followed by some of the biggest software producers—Visicorp, Microsoft Consumer Products, and Software Arts (creator of Visicalc and the TK Solver equation-solving package mentioned in last month's editorial). All three companies have developed programs that make use of enormous disk-based help files. By making help about the program available literally at the touch of a button, these manufacturers hope to make their programs easier to use. Another interesting move is toward the use of high-level computer languages to develop products that are easily transportable among various machines. Visicorp and Microsoft Consumer Products are using the C language, while Software Arts has developed its own proprietary language for in-house use. All three companies develop software on mainframe computers that have extensive diagnostic and performance evaluation features, and then they move the finished programs to microcomputers.

NEC's Advanced Personal Computer

NEC Information Systems Inc. showed its 8086-based Advanced Personal Computer (APC). The APC is available in two configurations—a monochrome configuration that includes CP/M-86, 128K bytes of memory, and two 8-inch 1-megabyte drives ($3998) and a color configuration that substitutes a 12-inch RGB (red-green-blue) color monitor for the monochrome monitor ($4998). The color-based unit is impressive: over 300K bytes of memory are used to give an 8-color 640- by 475-pixel display with no limitations on adjacent pixel colors. The actual graphics display is 1024 by 1024 pixels, and the video display is a movable window within that area. NEC has already lined up a comprehensive array of business software packages for its machine, something that's sure to continue as competition quickens and the industry matures.■

The Hanover Fair

by Robert E. Ramsdell

With nearly 9 million square feet of total exhibit space, individual displays the size of a football field, and close to 600,000 visitors, the Hanover Industrial Trade Fair and Exposition is the world's largest. Held this year from April 21 to 28 in Hanover, West Germany, this fair is a showcase for hundreds of manufacturers of office equipment and computers.

CeBIT, the world center for office equipment and data processing, had a display that covered 1.75 million square feet (about 20 percent of the total area) and spilled over into 5 buildings. To give you some idea of the scale of things in Hanover, CeBIT's space alone was about five times greater than that of America's largest computer show, the annual National Computer Conference held this year in June in Houston, Texas.

Some 178 U.S. companies were part of the CeBIT display. The United States Department of Commerce sponsored a group pavilion there. Among the 60 companies from the U.S. that joined together to exhibit their products in the European marketplace were Fortune, Corvus, Altos, Beehive, Durango, M/A-COM (Ohio Scientific), Micom, Morrow, and Televideo. In addition, Osborne, Tandy, Apple, Xerox, IBM, Centronics, Cromemco, Data General, Digital Equipment Corporation, Micropro, NCR, Burroughs, Texas Instruments, Prime, Shugart, Tandem, Teleram, Vector Graphic, Victor, and more had booths elsewhere in the show. On public display were anywhere from 73 to 95 different computer models; the count depended on whom I asked.

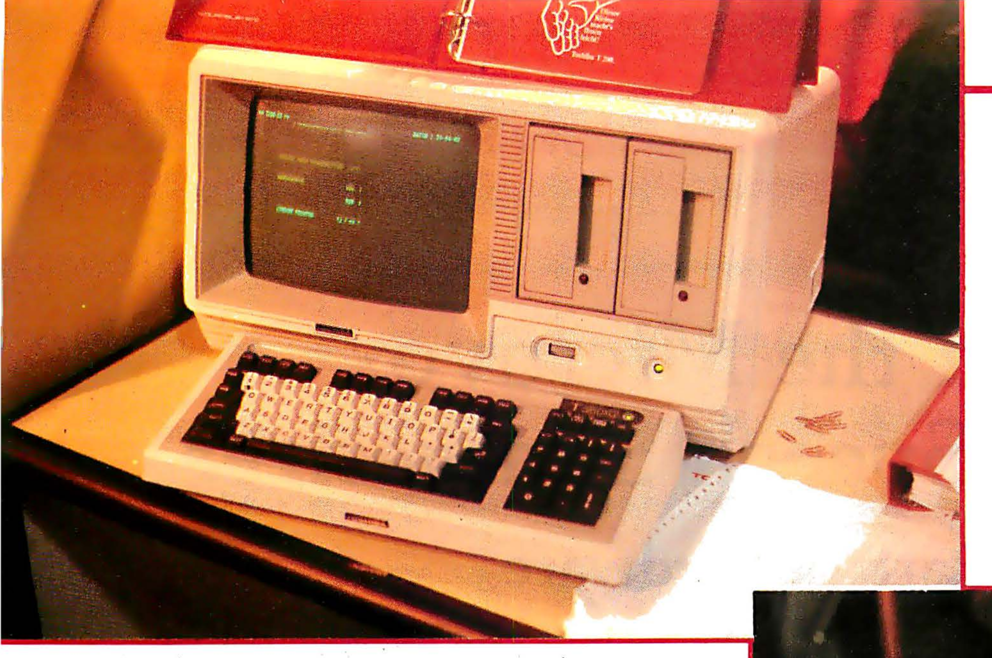
More than 30 Japanese computer manufacturers exhibited, and some of their booths were three stories tall. The Japanese showed many new (and slightly revamped) computer models, including about 20 16-bit machines, most of which run Microsoft's MS-DOS. The Intel chips (8086/8088) seemed to dominate these computers, but several models used the Motorola 68000.

To cope with the huge crowds attending the Hanover fair, the city of Hanover has established a private-room registry, with offices at the airport, train station, and the fair itself. The registry guaranteed a room, usually in a private home, to all visitors and exhibitors. Many Americans at the fair agreed that staying in a private home was a great cultural experience as well as a delightful and inexpensive way to absorb the German atmosphere and the **gemutlichkeit** (friendliness) of the German people. The language barrier never seemed to be a problem, either at the fair or around the city. ■

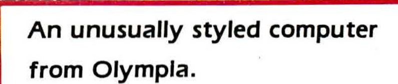
Pentel's new computer.



Robert E. Ramsdell, CPA, is a microcomputer consultant who lives and works in Rockport, Massachusetts. His company, Pansophics Ltd., publishes business- and financial-modeling applications software for use with Visicalc and Supercalc programs.



A new business computer from Toshiba.



An unusually styled computer from Olympia.



Another Japanese entry, from Sanyo.



The Epson HX-20 portable computer.

Build the Microvox Text-to-Speech Synthesizer

Part 1: Hardware

The 6502 microprocessor in this intelligent peripheral device translates plain English text into phonemes to control a Votrax SC-01A.

Steve Ciarcia
POB 582
Glastonbury, CT 06033

This month's project may have a strange ring of familiarity to those of you who follow my activities in the Circuit Cellar. Twice before, in June and September of last year, I have written about peripheral devices that give personal computers the ability to speak with an imitation of a human voice.

The September article (see reference 5) described the Sweet Talker speech synthesizer, which has since become especially popular. The original Sweet Talker, a parallel-interfaced synthesizer module programmed by phoneme (speech sound) codes, was quickly joined by a version that could be plugged into an Apple II computer and operated using a text-to-speech algorithm stored on a floppy disk.

But I wasn't satisfied. Neither the Sweet Talker nor my June project (see reference 4), the Micromouth, was flexible enough to fit the variety of applications I had envisioned. I could foresee applications requiring unlimited vocabulary (thus ruling out use of the Micromouth) that also need a smaller, more portable voice-synthesis system than could be made out of an Apple II. While I was content with the Sweet Talker's speech quality, I did not want to try converting the text-to-speech algorithm to run on my Z8-BASIC Microcomputer.

I next considered using the Votrax Type-'N-Talk. As a stand-alone voice synthesizer with a built-in microprocessor and 4K-byte text-to-speech algorithm, it does quite well considering its moderate cost (see reference

General-Purpose Computer

The 6502-based microcomputer that forms an integral part of the Microvox is ideal for use in many other small-scale applications. Only the application software and the interface to the SC-01A chip are specific to the microcomputer's use in the stand-alone text-to-speech voice synthesizer. If you are among the many readers who write to me asking for suggestions on how to put together a low-priced, general-purpose microcomputer system, you should consider building the computer part of the Microvox design.

The computer section contains, among other things, a 1-MHz 8-bit 6502 microprocessor, a serial input port that can run at crystal-controlled data rates from 75 to 19,200 bps (bits per second) with full handshaking, 3 parallel input ports, provision for up to 4K bytes of RAM (random-access read/write memory) and 16K bytes of EPROM (erasable programmable read-only memory), and an on-board power supply. It is suitable for use as a learning tool for computer concepts, as a dedicated device controller, or as the center of an expanded microcomputer system (similar to systems that have been built around the MOS Technology KIM-1 or the Rockwell AIM-65).

The Micromint will be supplying essential components of the microcomputer section of the Microvox for those who wish to experiment with it. And you may expect to see the same 6502-based control-computer design in future Circuit Cellar projects.

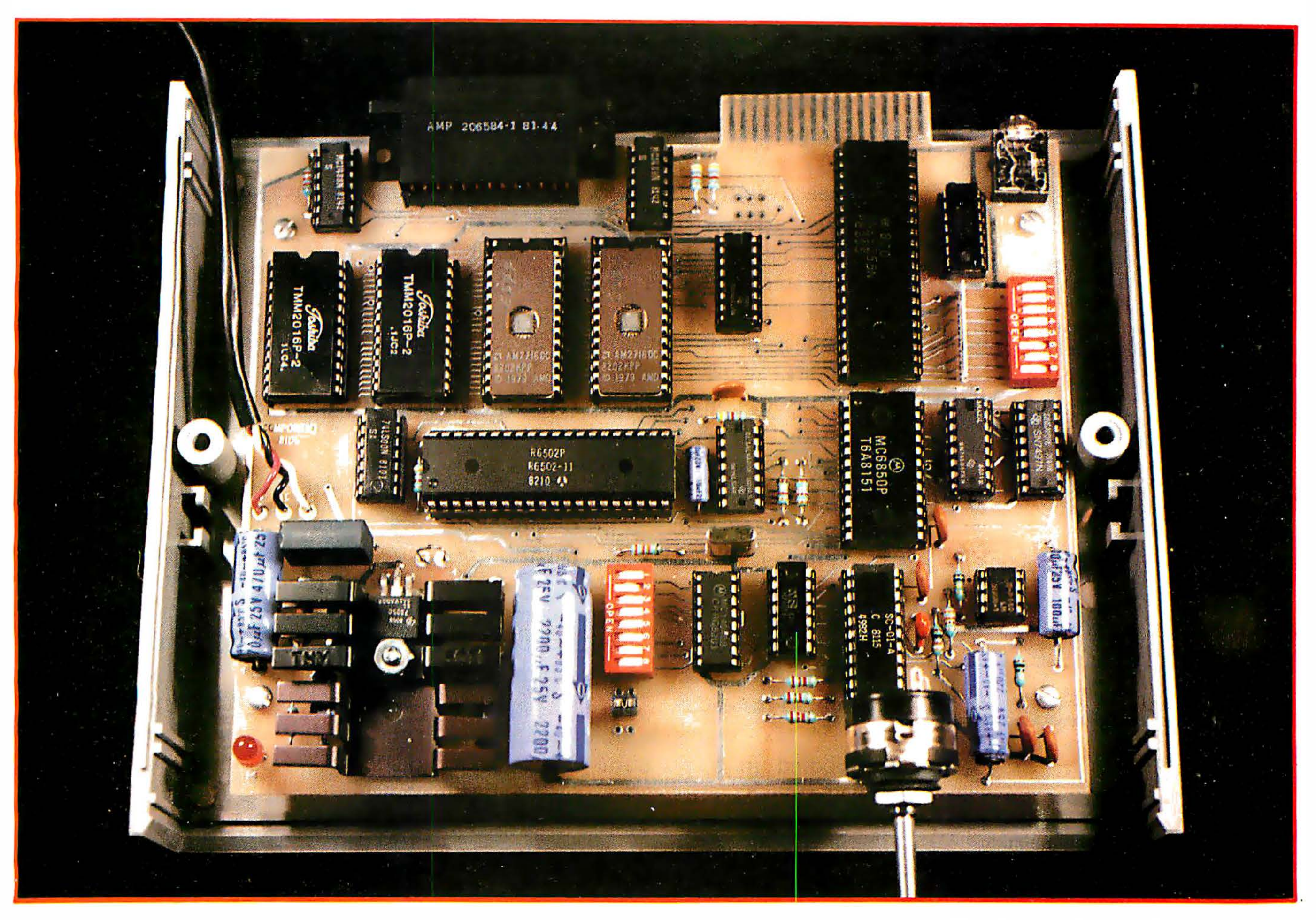


Photo 1: *Prototype of the Microvox speech synthesizer, which can pronounce texts consisting of English words from their representation as ASCII characters according to fixed pronunciation rules. The Microvox contains a general-purpose 6502-based microcomputer programmed to control the Votrax SC-01A-based speech-synthesis circuitry.*

12). However, its design is somewhat limited for commercial applications.

Not finding any other suitable product on the market, I did what any red-blooded engineer would naturally do: I decided to design an improved text-to-speech voice synthesizer.

You are reading the first of two articles on the design, construction, and operation of a text-to-speech voice synthesizer I call the Microvox. This new device, like the Sweet Talker, is based on the Votrax SC-01A speech-synthesis integrated circuit, but it incorporates new functions (most notably pitch inflection) and a larger, more complex control program. A list of its features appears in table 1 on page 66.

To support its various functions, the Microvox contains a general-purpose 6502-based microcomputer programmed to control the speech-synthesis circuitry. Program routines stored in ROM (read-only memory) activate various control options upon the user's command; the most complex of the routines performs the crucial task of translating the Microvox's input—a stream of text represented by ASCII (American Standard Code for Information Interchange) character codes—into the special phoneme codes required by the SC-01A chip. Incidentally, this 6502-based microcomputer is ideal for use in many other small-scale applications, as the text box explains.

As with many Circuit Cellar projects, the Microvox design has been cast in printed circuit, and I have arranged for The Micromint to offer a kit of the parts needed to build it. Furthermore, an assembled, FCC- (Federal Communications Commission) approved version of the unit is being sold by Intex Micro Systems Corporation under the trade name Intex Talker. Information on availability of both products appears at the end of this article.

I cannot thoroughly cover such a comprehensive topic in one article, so this month I shall present only the hardware and a brief overview of the system commands. Next month in Part 2, I'll discuss the design of the text-to-speech algorithm and the system software.

Let's begin with an explanation of what we are trying to accomplish and a brief review of the Votrax SC-01A chip and phonetic speech synthesis in general.

Text-to-Speech Background

Many articles in BYTE and other technical magazines have been devoted to the topic of computer speech synthesis. In general, they have dealt more with the production of the

1. Phoneme-based speech synthesis
2. 6502 control microprocessor
3. 64 crystal-controlled inflection levels
4. 1K-character buffer (optionally expandable to 3K)
5. 6K-byte plain-text-to-phoneme algorithm
6. Full ASCII character-set recognition and echo
7. Adjustable data rates (150 to 9600 bits per second)
8. RS-232C and parallel input interfaces
9. Phoneme access modes
10. Serial X-on/X-off software handshaking
11. User-expandable memory
12. 1-watt audio amplifier with volume control
13. On-board power supply
14. Music and sound effects

Table 1: *Major characteristics of the Microvox text-to-speech synthesizer (and of its alter ego, the Intex-Talker).*

Code	Function
!K	synchronize speech and text
!L	line-by-line pronunciation
!W	whole-text pronunciation
!E	each-letter pronunciation
!C	pronounce by direct phoneme input
!T	pronounce by text-to-speech algorithm
!N	play musical notes
!A	pronounce all punctuation
!M	pronounce most punctuation
!S	pronounce some punctuation
!F	set monotone or flat intonation
!I	set automatically inflected intonation
!P*x*	set intonation base pitch (where x = 1 to 4)
!R*y*	set intonation clock rate (where y = 1 to 16)

Table 2: *An incomplete list of some of the control codes and sequences used by the Microvox, with their functions. Part 2 of this article will contain more detail concerning the Microvox's control capabilities.*

speech interface and the technology of specific synthesizers than with the applications to which speech synthesis may be put. Such treatment is similar to comparing computer systems by their processor instruction sets only instead of the high-level-language software available for them. Today, far more computer users are concerned with applications than with construction of computers or peripheral devices. The Microvox is designed for easy use in a wide variety of applications.

With the majority of low-cost speech-synthesizer interfaces, the user must arrange for conversion of the material to be spoken from textual characters to data that the speech synthesizer can work with (phonemes, linear-predictive-coding formants, word codes, etc.). The difficulty of conversion depends largely on the size of the required vocabulary. For small vocabularies, a table of words and their corresponding synthesizer codes can be compiled with reasonable effort. When the required vocabulary becomes very large, all-inclusive tables become prohibitively cumbersome, and a generalized text-to-speech algorithm is required instead.

A text-to-speech algorithm is embodied in a program that accepts ASCII characters as input and performs a synthesis-by-rule analysis of character strings; that is, the algorithm interprets the characters as words or other elements of language and devises a scheme for pronouncing them according to a fixed set of rules that determine which characters are voiced, and in what way, and which characters are silent. The rules are based on how given combinations of characters are pronounced most of the time in English (or the language in use).

Text-to-speech programs vary in length depending upon the degree of exactness required in pronunciation. Typical algorithms use from 4K to 8K bytes of object code for most processors, but some of the more sophisticated programs need up to 80K bytes. (Often, half of an 80K-byte synthesis-by-rule routine consists of tables of words that are exceptions to the rules.)

The primary difference you can see between a 6K-byte and a 20K-byte program is how the input text must be spelled to obtain acceptable pronunciation; the final sound quality may be the same. Certain words may be spelled unusually to fit the prescribed pronunciation rules of the smaller algorithm. For instance, my name, Ciarcia, is properly pronounced by most synthesizers (and by a lot of people, come to think of it) only when it is spelled "see-are-see-ah." The only other major differences are features such as pronunciation of punctuation or inflected speech. (Both of these capabilities are supported by the Microvox.)

Strengths of Microvox

While there are many speech-synthesizer interfaces designed to be used with a variety of personal computers, packaging the text-to-speech algorithm with its own dedicated processor greatly simplifies the integration of any system. By creating an intelligent peripheral device, we don't have to depend on operating systems and application programs to support speech synthesis.

The Microvox text-to-speech synthesizer is just such a smart peripheral device. It speaks any ASCII character string directed to it through either its serial or parallel input ports. The ASCII text can come from PRINT statements in a BASIC program or from a previously prepared disk file. Microvox connects to the computer in the same manner as a printer or modem, and virtually anything that can be printed or viewed on the terminal screen can be spoken.

The Microvox is controlled by the host computer through that same connection by means of special character sequences either transmitted before the text to be spoken or embedded in it. These control sequences are in the form:

!letter,numeral

The exclamation point is a signal to the Microvox that a control sequence follows. Operating modes and options can be changed at any time by sending the appropriate sequences. Table 2 lists some of the control sequences and their functions. I'll write about the intricacies of the Microvox text-to-speech algorithm and the control capabilities next month.

SC-01A Phoneme Synthesizer

As I mentioned before, the Microvox is a combination of two major

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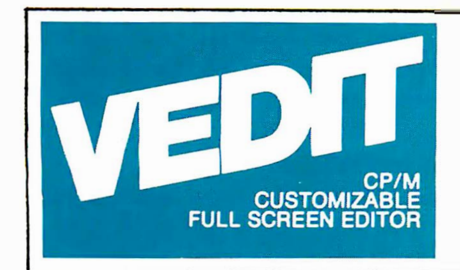
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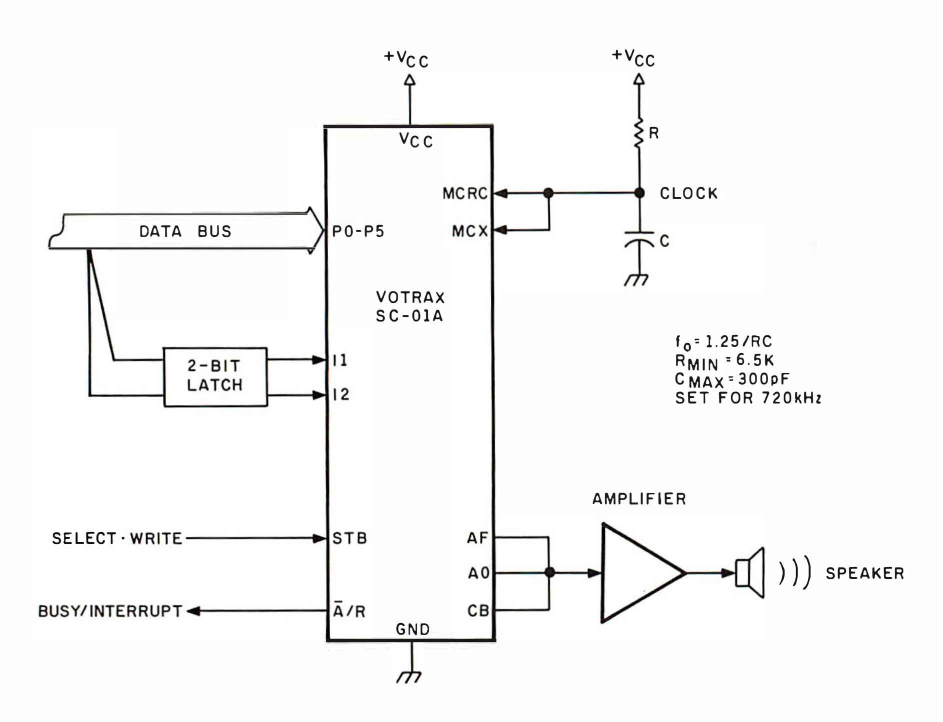


Figure 1: *The general scheme to be followed in connecting the Votrax SC-01A to a microcomputer system.*

elements: a 6502-based control microcomputer and a Votrax SC-01A speech-synthesizer chip. I explained the SC-01A in detail in last September's Circuit Cellar article (reference 5), but for new readers I'll summarize the important facts.

The SC-01A is a 22-pin integrated circuit which consists of a digital code translator and an electronic model of the human vocal tract. The internal phoneme controller translates a 6-bit phoneme code and 2-bit pitch code into a matrix of spectral parameters that adjust the vocal-tract model to synthesize speech.

The SC-01A is manufactured using CMOS (complementary metal-oxide semiconductor) technology and operates within a range from +7 to +14 V. Handshaking with external control circuitry is accomplished through a strobe (STB) line and an acknowledge/request (Ā/R) line. A diagram of the generalized connection scheme appears as figure 1.

The output pitch of the SC-01A's voice is controlled by the frequency of the clock signal, which can either be supplied from an external source or set internally with a resistor/capacitor combination. The clock frequency is nominally 720 kHz, but subtle variations of pitch can be induced to add inflection by varying this frequency. Such variations prevent the synthesized voice from sounding too monotonous or artificial. Two separate pitch-control lines, I1 and I2, are available for gross variations in pitch so that the chip can seem to speak with more than one voice. These so-called manual-inflection controls operate independently of clock-rate-induced inflection.

The 64 SC-01A phonemes defined for the English language are listed in table 3 on page 72. Most of these correspond to speech sounds, but two produce silence and one causes speech synthesis to stop. The sound for each phoneme is generated when a 6-bit phoneme code is placed on the control-register input lines (P0 through P5) and latched by pulsing the strobe (STB) input. Each phoneme is internally timed and has a duration ranging from 47 to 250 ms (milliseconds) depending on the phoneme selected

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Hexadecimal Phoneme Code	Phoneme Symbol	ASCII Character	Duration (ms)	Example Word
00	EH3	@	59	jacket
01	EH2	A	71	enlist
02	EH1	B	121	heavy
03	PA0	C	47	no sound
04	DT	D	47	butter
05	A2	E	71	make
06	A1	F	103	pail
07	ZH	G	90	pleasure
08	AH2	H	71	honest
09	I3	I	55	inhibit
0A	I2	J	80	inhibit
0B	I1	K	121	inhibit
0C	M	L	103	mat
0D	N	M	80	sun
0E	B	N	71	bag
0F	V	O	71	van
10	CH	P	71	chip
11	SH	Q	121	shop
12	Z	R	71	zoo
13	AW1	S	146	lawful
14	NG	T	121	thing
15	AH1	U	146	father
16	OO1	V	103	looking
17	OO	W	185	book
18	L	X	103	land
19	K	Y	80	trick
1A	J	Z	47	judge
1B	H	[	71	hello
1C	G	\	71	get
1D	F	]	103	fast
1E	D	^	55	paid
1F	S	_	90	pass
20	A	(space)	185	tame
21	AY	!	65	jade
22	Y1	"	80	yard
23	UH3	#	47	mission
24	AH	$	250	mop
25	P	%	103	past
26	O	&	185	cold
27	I	'	185	pin
28	U	(	185	move
29	Y	)	103	any
2A	T	*	71	tap
2B	R	+	90	red
2C	E	,	185	meet
2D	W	–	80	win
2E	AE	.	185	dad
2F	AE1	/	103	after
30	AW2	0	90	salty
31	UH2	1	71	about
32	UH1	2	103	uncle
33	UH	3	185	cup
34	O2	4	80	bold
35	O1	5	121	aboard
36	IU	6	59	you
37	U1	7	90	June
38	THV	8	80	the
39	TH	9	71	thin
3A	ER	:	146	bird
3B	EH	;	185	ready
3C	E1	<	121	be
3D	AW	=	250	call
3E	PA1	>	185	no sound
3F	STOP	?	47	no sound

Note: T must precede CH to produce "CH" sound.
D must precede J to produce "J" sound.

Table 3: *The 64 SC-01A phonemes defined for the English language. Most of these correspond to speech sounds; two produce silence, and one causes speech synthesis to stop.*

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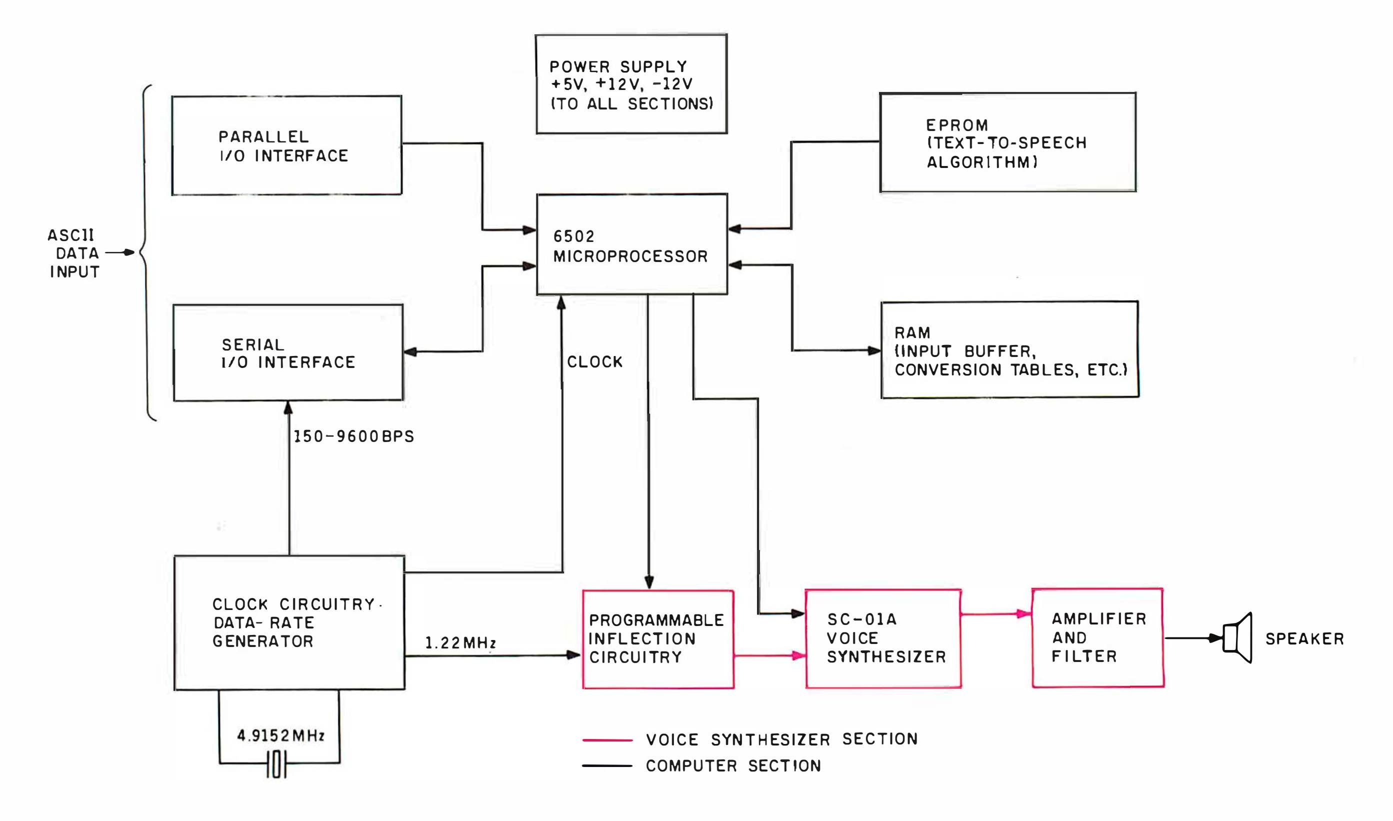


Figure 2: *Block diagram of Microvox. The Microvox hardware can be viewed as a general-purpose 6502-based computer with a speech synthesizer attached using a memory-mapped I/O (input/output) port.*

The computer section (shown in black) uses 14 integrated circuits for serial and parallel I/O, address decoding, memory, and other processing functions. Five additional chips (outlined in red) constitute the phoneme synthesizer, inflection circuitry, and audio amplifier.

and the clock frequency. The $\overline{A}$/R line goes from a logic 1 to a logic 0 while a phoneme is sounding.

The usual method for using the SC-01A with a microprocessor sets up the hardware so that the computer system directly times the transmission of phoneme codes. This method sends phoneme codes to the synthesizer chip through a latched parallel output port and monitors the synthesizer's activities through the $\overline{A}$/R line, which is connected to an input port or interrupt line.

Microvox Hardware Overview

Figure 2 is a basic block diagram of Microvox. As previously mentioned, the Microvox contains its own microcomputer that allows the unit to be configured to function as an intelligent peripheral device; therefore, the Microvox hardware can be viewed as a general-purpose 6502-based computer with a speech synthesizer attached using a memory-mapped I/O (input/output) port.

The computer section uses 14 integrated circuits for serial and parallel I/O, address decoding, memory, and other processing functions. Five additional chips constitute the phoneme synthesizer, inflection circuitry, and audio amplifier (outlined in red).

Variations in pitch prevent the synthesized voice from sounding too monotonous or artificial.

The Microvox is best explained by dividing the circuitry into four functional subsections: processor and timing, memory, serial and parallel I/O, and speech synthesizer. A complete schematic diagram of Microvox appears as figure 3a on pages 76 and 77 and figure 3b on pages 78 and 79.

Processor and Data-Rate Clock

The 1-MHz (megahertz) 6502 microprocessor, the same type used in the Apple II and Atari 800 computers, and the data-rate generator (shown by itself in figure 4 on page 80) obtain their clock signals from a circuit that divides down a 4.9152-MHz frequency from a crystal-controlled oscillator. You may find the rationale for using this low-cost clock divider interesting.

Most data-rate-generator circuits are very costly because they use specialized data-rate generator chips such as the COM5016, which you must have if you really need to cover 134.5 and 110 bps (bits per second) as well as the other standard data rates from 75 to 19,200 bps. The former two data rates are the only ones that require oddball frequencies. If you can get along without them (and most people can nowadays), no special divider networks or integrated circuits are required. By using a 4.9152-MHz (75×2^{16}) base frequency and a 12-stage binary divider (a CD4040, IC6 in figure 4), the nine remaining rates are derived directly.

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Recently we introduced new enhancements to make the DS180 printer even more versatile. Dot addressable raster scan graphics produces output of computer generated charts, maps and graphs at a resolution of 75 x 72 dots per inch. Variable horizontal pitch selection allows printing at 10, 12 or 16.5 characters per inch plus double wide printing at 5, 6 or 8.25 characters per inch. The expanded 2K FIFO print buffer handles a full CRT screen dump at up to 9600 baud without delaying the host system. We also offer transparent mode for isolating communications problems, and for APL users, the dual ASCII/APL character set option.



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DS180 PRINTER STANDARD FEATURES
- Microprocessor Control
- 180 CPS Print Speed
- Bidirectional/Logic Seeking
- 1000 Character Buffer (Expandable)
- 9x7 Dot Matrix
- Expanded Characters
- Adjustable Printhead/1-6 Copies
- 96 ASCII Character Set
- Cartridge Ribbon
- 132 Column Print Width
- Tractor Feed (Front or Bottom)
- Non-Volatile Format Retention
- Top of Form
- Horizontal Tabs
- Vertical Tabs
- Perforation Skip-Over
- Auto Line Feed
- 6/8 LPI
- Auto End of Line Carriage Return
- 5 IPS Paper Slew
- Parallel and Serial Interfaces
- 110-9600 Baud Communications
- Terminal Status Indicators
- Audio Alarm
- Self-Test
- X-on, X-off
- Paper Out Detection

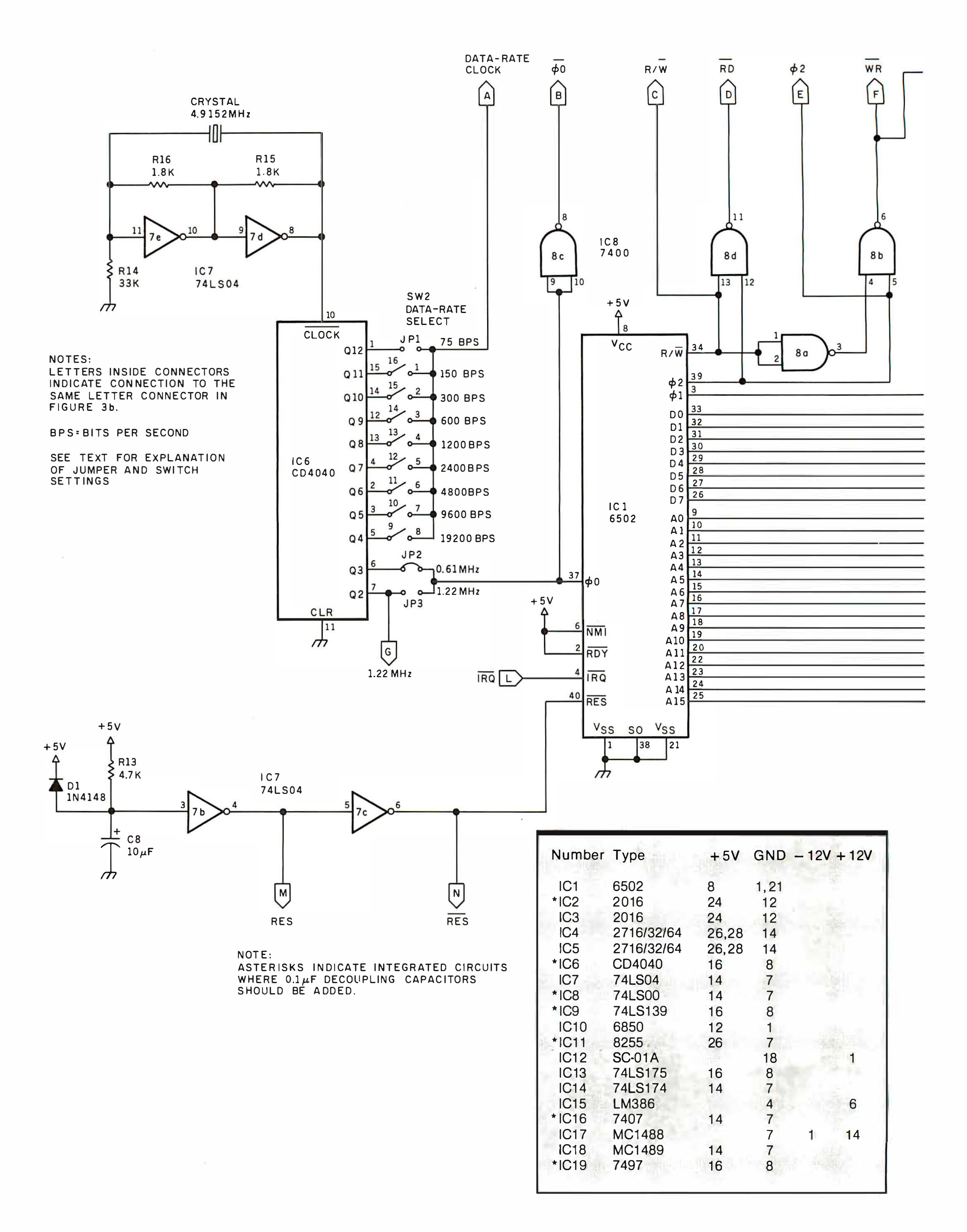
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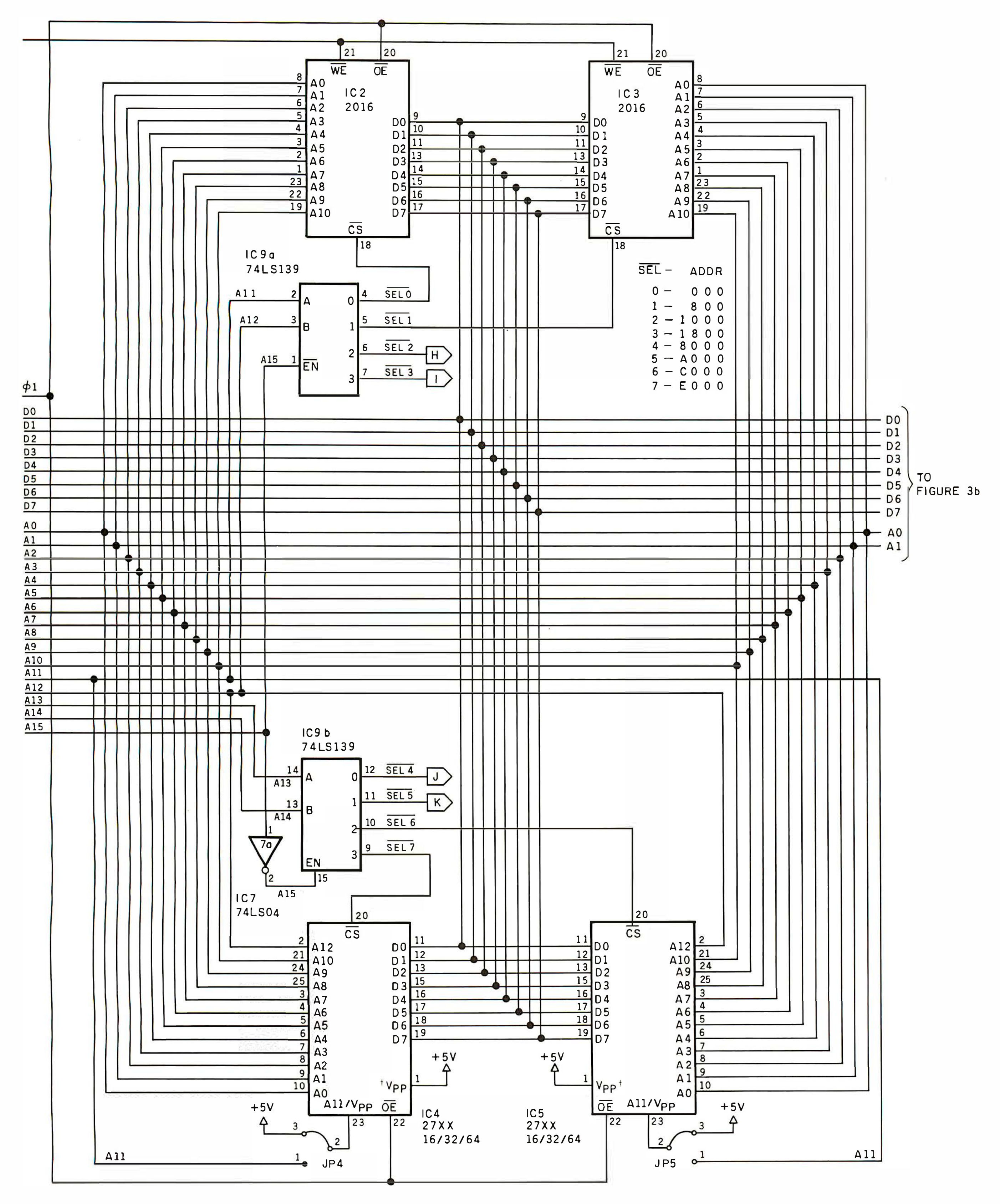
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Number	Type	+5V	GND	−12V	+12V
IC1	6502	8	1,21		
*IC2	2016	24	12		
IC3	2016	24	12		
IC4	2716/32/64	26,28	14		
IC5	2716/32/64	26,28	14		
*IC6	CD4040	16	8		
IC7	74LS04	14	7		
*IC8	74LS00	14	7		
*IC9	74LS139	16	8		
IC10	6850	12	1		
*IC11	8255	26	7		
IC12	SC-01A		18		1
IC13	74LS175	16	8		
IC14	74LS174	14	7		
IC15	LM386		4		6
*IC16	7407	14	7		
IC17	MC1488		7	1	14
IC18	MC1489	14	7		
*IC19	7497	16	8		

Figure 3a: *A section of the Microvox schematic diagram. Shown here are the 6502 microprocessor and the timing section. The schematic is continued in figure 3b on the next two pages.*


IC2
2016
IC3
2016
WE
OE
CS
IC9a
74LS139
SEL 0
SEL 1
SEL 2
SEL 3
SEL – ADDR
0 – 000
1 – 800
2 – 1000
3 – 1800
4 – 8000
5 – A000
6 – C000
7 – E000
φ1
TO FIGURE 3b
IC9b
74LS139
SEL 4
SEL 5
SEL 6
SEL 7
IC7
74LS04
IC4
27XX
16/32/64
IC5
27XX
16/32/64
A11/VPP
+5V
JP4
JP5
† = 2764 ONLY

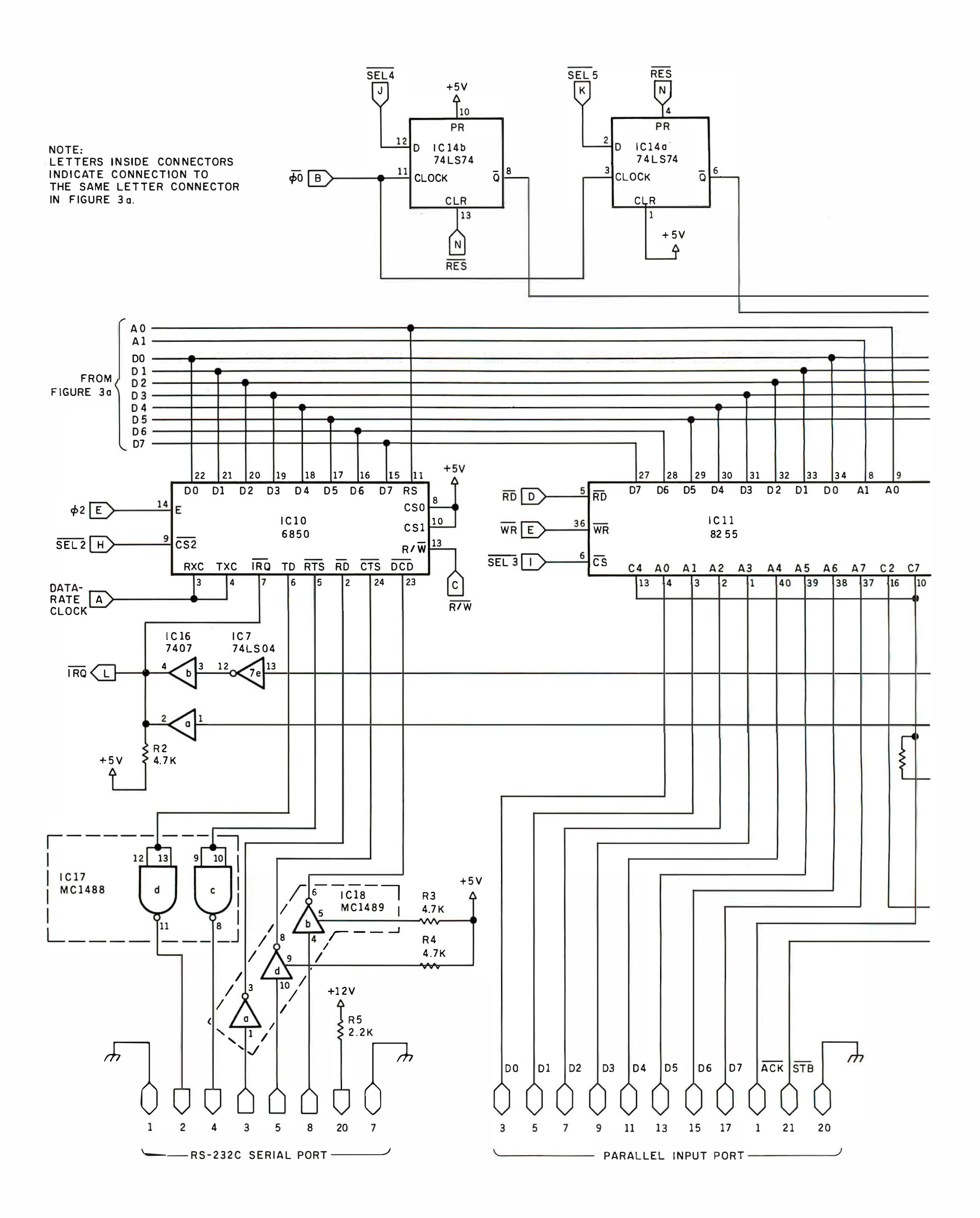
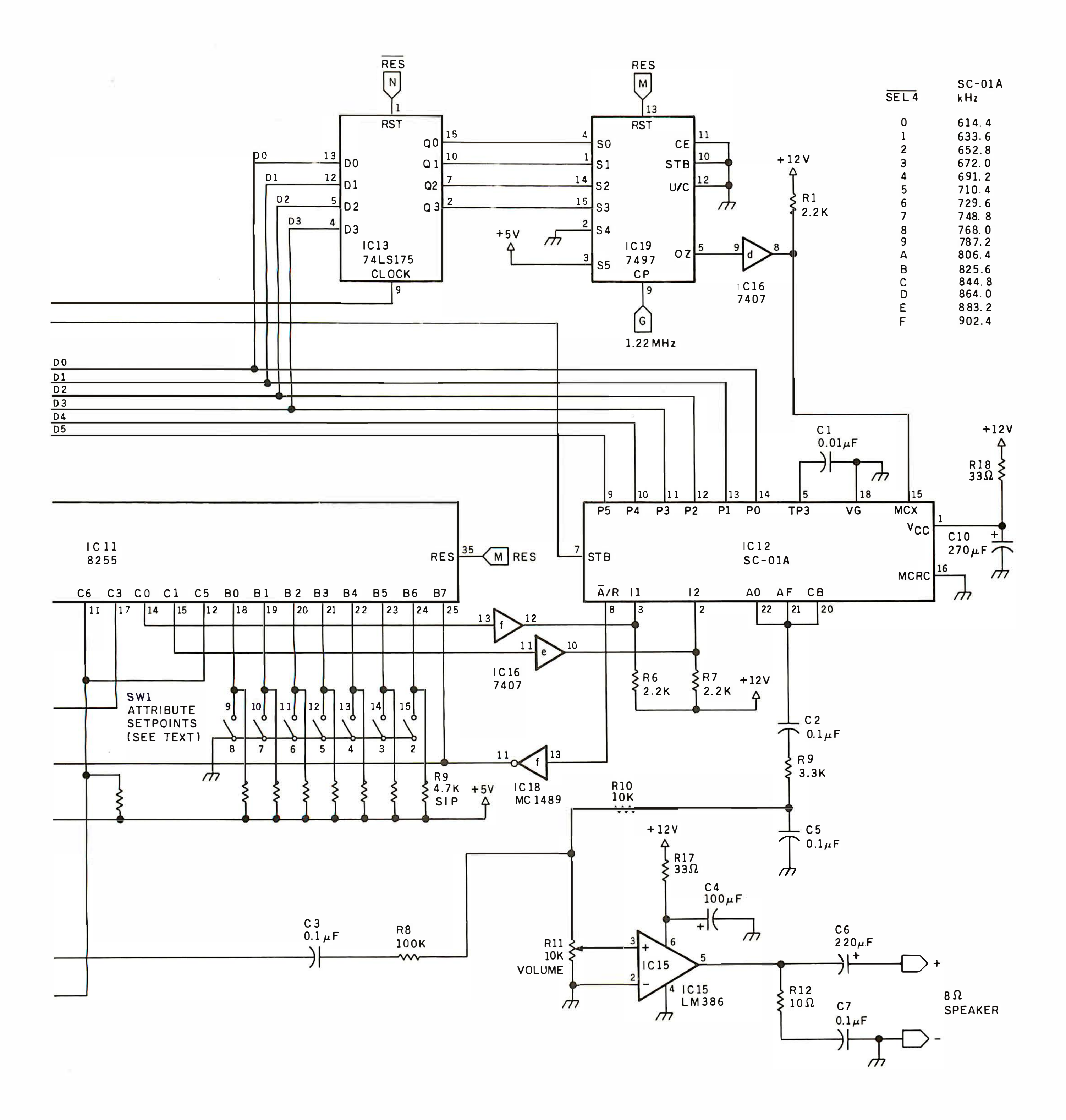


Figure 3b: *A section of the Microvox schematic diagram, featuring the serial and parallel I/O and the SC-01A speech-synthesis integrated circuit.*



This approach does require one other design compromise. The 6502 processor is specified to operate at 1 MHz, but, using this crystal and divider circuit, only 611 kHz and 1.22 MHz are available as system-clock signals. The computer must run at either 61 percent or 122 percent of its rated speed.

Practically speaking, this is not a problem. The 1-MHz specification is for worst-case conditions, which you probably will not have. I have personally run 1-MHz 6502s at 1.8 MHz with no trouble. Furthermore, in the Microvox application, we can note that the speech synthesizer requires data at only about 200 bps to speak continuously. Processor speed is just not significant except when receiving and manipulating data at 19,200 bps. Just to be on the conservative side, while the hardware can produce rates from 75 to 19,200 bps, I have specified rates of 150 to 9600 bps for the Microvox.

Memory Section

The address-decoding and memory section of the Microvox consists of

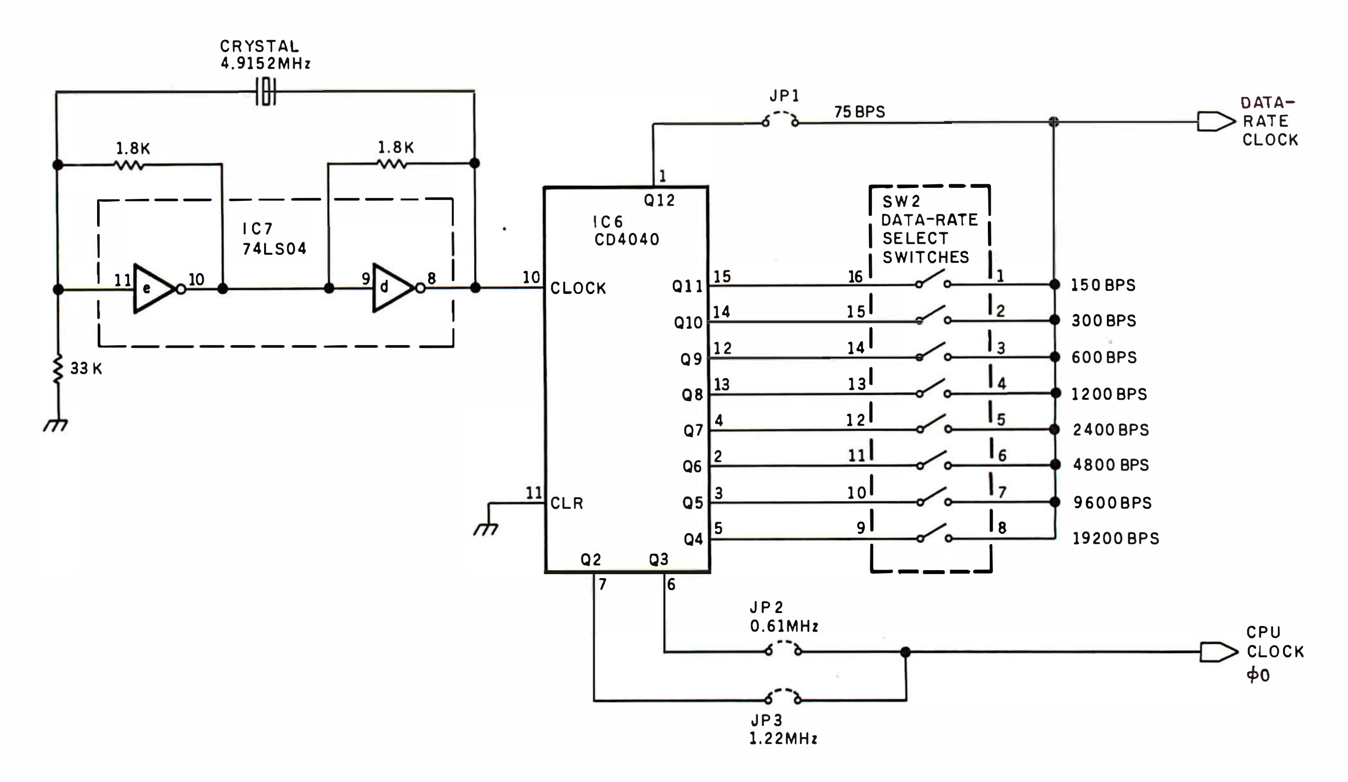


Figure 4: *A detail from the Microvox circuit, showing the circuitry that derives the data-rate and clock frequencies. With this simple, low-cost arrangement, all standard data rates, except 110 bps (bits per second) and 134.5 bps, are available. Also, a trade-off must be made in selecting a clock rate for operating the microprocessor.*

Name	Hexadecimal Address	Connection and Function
$\overline{\text{SEL0}}$	000	IC2 memory block (RAM)
$\overline{\text{SEL1}}$	800	IC3 memory block (RAM)
$\overline{\text{SEL2}}$	1000	IC10 serial port
$\overline{\text{SEL3}}$	1800	IC11 parallel ports
$\overline{\text{SEL4}}$	8000	IC14 inflection clock rate
$\overline{\text{SEL5}}$	A000	IC14 phoneme latch
$\overline{\text{SEL6}}$	C000	IC5 memory block (EPROM)
$\overline{\text{SEL7}}$	E000	IC4 memory block (EPROM)

Table 4: *The 5 high-order bits on the 6502 address bus are decoded by IC9 to provide 8 strobe signals that control various parts of the system.*

IC2 through IC5 and IC9. IC9 (a 74LS139) decodes the 5 high-order bits on the address bus to provide 8 strobe signals, as listed in table 4.

In the Microvox configuration, memory components IC2 and IC3 are intended to be RAM, while IC4 and IC5 are meant to be ROM or EPROM (erasable programmable read-only memory). The pin designations for IC2 and IC3 are for 2K-by-8-bit RAM chips, such as the Hitachi 6116 or Toshiba 2016. These components are pin-compatible with the type-2716 EPROM, so you could use 2716s in these sockets instead, if the computer were being used in some other application.

The read/write memory (IC2 and IC3) is used for conversion tables and register stacks and as the ASCII input buffer. A buffer is required because the Microvox can receive data faster than it can speak it. The standard Microvox uses only one RAM chip (installed as IC2), which provides a 1K-byte input buffer; by adding the second RAM chip in IC3, this can be optionally expanded to 3K bytes of text memory (for long-winded speeches).

The text-to-speech conversion routine for the standard Microvox is stored in 8K bytes, presently consisting of two type-2732 EPROMs inserted in the sockets for IC4 and IC5. As production increases or EPROM prices drop, a single 8K-byte 2764 EPROM (or its ROM equivalent) will be used. Any of the compatible type-2716 (2K-by-8-bit), type-2732 (4K-by-8-bit), or type-2764 (8K-by-8-bit) EPROMs can be used in these IC positions, depending upon the jumper selections JP4 and JP5.

Serial and Parallel I/O

Microvox, unlike most other voice synthesizers, has both serial and parallel input ports to receive ASCII characters. The serial port uses a Motorola MC6850 ACIA (asynchronous communications interface adapter, IC10). During system initialization, the ACIA's functional

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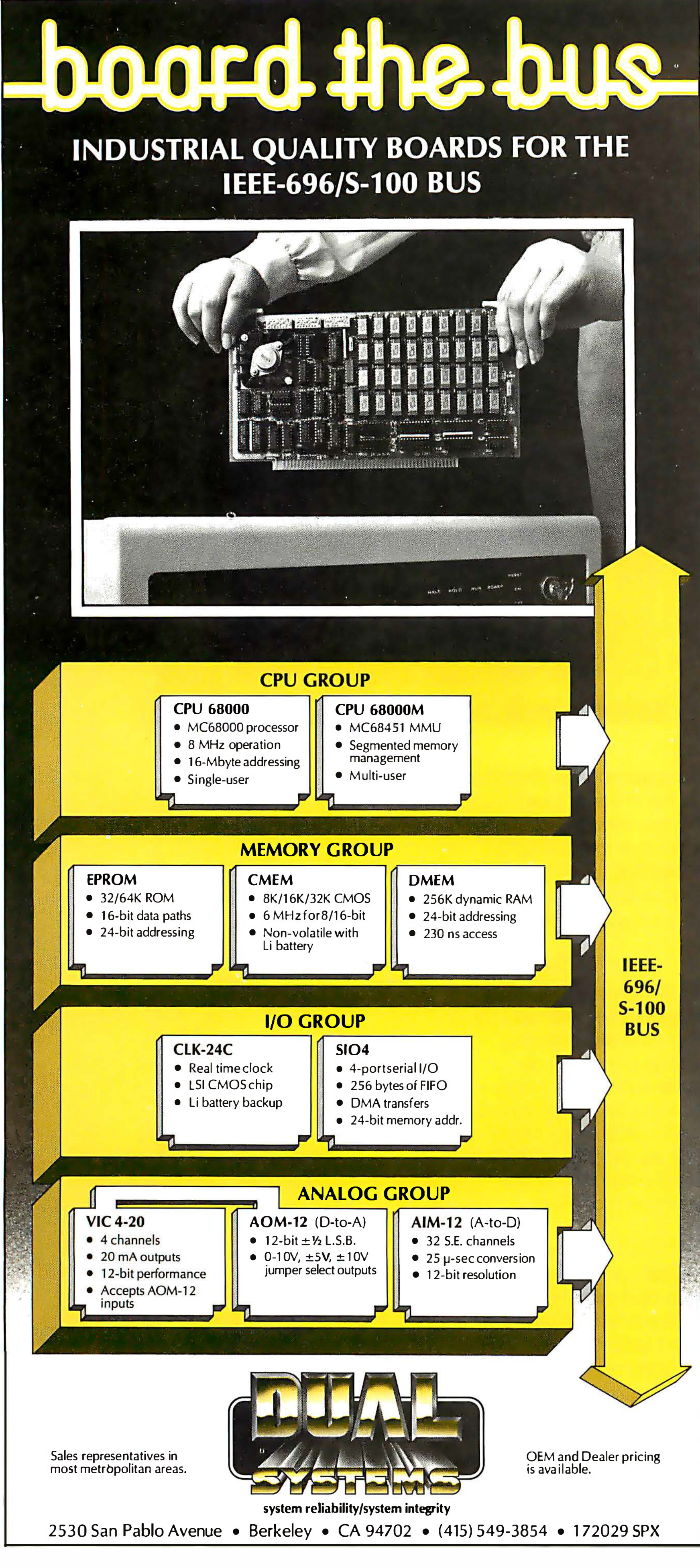
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configuration is set up; communication parameters such as character word length, clock division ratios, parity, and stop bits are selected by setting the proper bits in the ACIA's control register. The data rate is set by the system data-rate clock (from SW2 and IC6), and data is sent and received from the transmit- and receive-data registers, respectively. Framing errors, parity errors, buffer status, and handshaking status are determined by reading the ACIA's status register.

On the Microvox, the serial port can be used with or without hardware handshaking, that is, with or without using the RS-232C Clear to Send, Data Carrier Detect, Ready to Send, and other lines. The Microvox software incorporates software handshaking, which is especially useful when communicating over a modem link or with terminals that do not use handshaking signals.

When receiving ASCII text in the software-handshaking mode, the Microvox sends an "@" (at sign) to the host computer when its input buffer is almost full, signaling the host to stop sending data. The Microvox sends a "#" (number sign) when it is ready to receive data again. (The characters used for signaling can *be* changed to the X-on and X-off control characters if need be.)

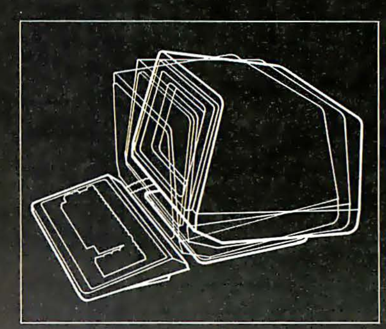
Obviously, this handshaking is not needed if the data comes from the host at a speed slower than the rate at which the buffer is emptied. The parallel-input section uses a programmable Intel 8255 PIA (peripheral interface adapter, IC11). As configured, 8 bits of the PIA are used to receive ASCII data in parallel format. By using two additional connections for data-available-strobe and acknowledge signals, the Microvox can be made to work with a Centronics-compatible parallel printer interface.

Also attached to the PIA is the DIP (dual-inline pin) switch SW1, which can be used to select operating parameters as follows. Bit 0 selects hardware or software handshaking; bit 1 selects receipt of the ASCII input data through the serial or parallel port; bits 2 through 4 set the serial-

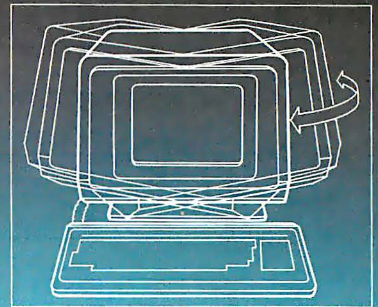
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Detached Keyboard	YES	NO	YES	NO	NO
N-Key Rollover	YES	NO	YES	NO	NO
Audible Key Click	YES	YES	NO	NO	NO
Menu Set-Up Mode	YES	NO	NO	NO	NO
Status Line	YES	NO	NO	NO	NO
Full 5 Attribute Selection	YES	NO	NO	NO	YES
Smooth Scroll	YES	NO	NO	NO	NO
Line Drawing Character Set	YES	NO	NO	NO	NO
Block Mode	YES	YES	NO	NO	YES
Insert/Delete Line	YES	YES	NO	NO	YES
Bi-Directional Aux Port	YES	YES	NO	YES	NO
Columnar Tabbing	YES	YES	NO	NO	YES
Independent RCV/TX Rates	YES	NO	NO	NO	NO
Answerback User Programmable	YES	NO	NO	OPT.	NO

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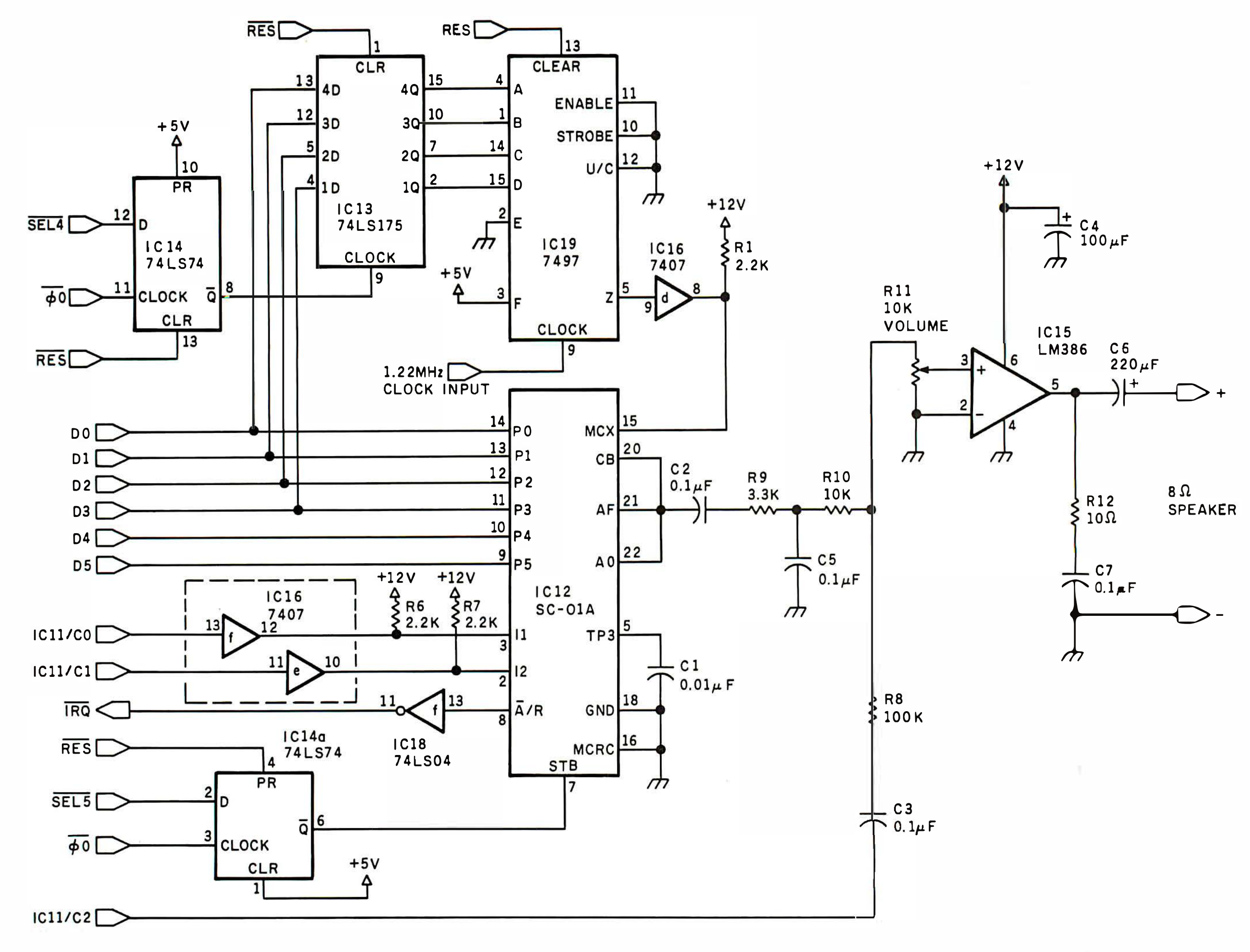


Figure 5: *The business end of the Microvox, the circuitry that actually produces the artificial voice. This design is similar to the Sweet Talker speech synthesizer; it is based also on the Votrax SC-01A integrated circuit. The main improvement is provision for 64 levels of pitch inflection, instead of the 4 levels available on the Sweet Talker.*

input word length, stop bits, and parity on the ACIA; and bits 5 through 7 are not used.

Speech Inflection

The business end of the Microvox, the circuitry that actually produces the artificial voice, is shown in the schematic diagram of figure 5. Regular followers of Circuit Cellar projects will recognize the Votrax SC-01A integrated circuit and notice that this design is similar to the Sweet Talker speech synthesizer from last September's article. This time, however, I have provided for 64 levels of pitch inflection, instead of the 4 levels previously available.

The output pitch of the phonemes is fundamentally controlled by the frequency of the clock signal provided to the SC-01A. In general use, this frequency, set with a resistor/capacitor combination, is nominally 720 kHz. But as with any current-controlled analog circuit, the frequency may be susceptible to change from temperature variation and pickup of external noise.

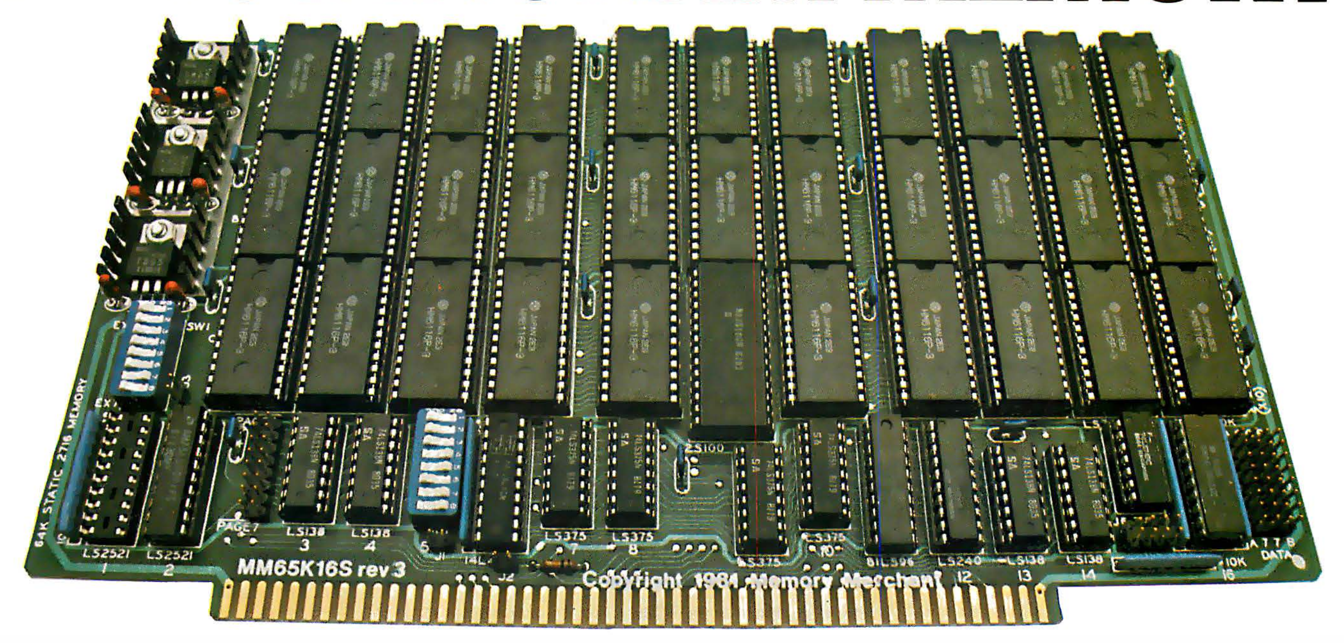
Coarse variations in pitch are best used for simulating completely different speaking voices.

In the Microvox, the analog clock circuitry is eliminated. Instead of using the SC-01A's internal timing circuit, the chip is configured for input of an external clock signal, derived from the crystal-controlled system clock.

While the fundamental range of the output pitch is a function of the clock frequency, the two pitch-control lines I1 and I2 (the "manual-inflection" lines) can act independently to cause four coarse variations in pitch from the fundamental setting. I think that these coarse variations are best used for simulating completely different speaking voices rather than for vocal inflections. The frequency shift is simply too great.

The preferred way to influence the output pitch is by changing the external clock frequency fed into the SC-01A, although this takes more work. Subtle variations in output pitch can be obtained with reasonable effort, by shifting the clock frequency up or down by 20 or 40 kHz. And by apply-

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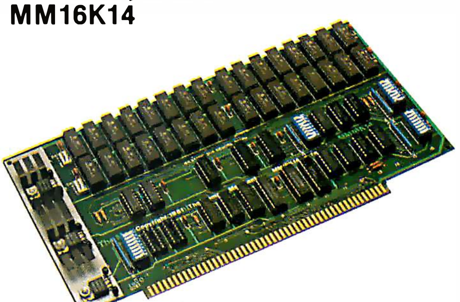
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ing a digital rate multiplier to the 1.22-MHz system clock, the signal input to the SC-01A can be made programmable to produce smaller and better-defined pitch inflections.

IC19 in the Microvox is a 6-bit binary rate multiplier. Its output frequency obeys the function:

$$F_{OUT} = M \times F_{IN}$$

where

$$M = b5 \times 32 + b4 \times 16 + b3 \times 8 + b2 \times 4 + b1 \times 2 + b0 \times 1$$

(*b5* through *b0* being the six multiplier bits) and

$$F_{IN} = 1.22 \text{ MHz}$$

When the $\overline{SEL4}$ strobe is activated, a 4-bit inflection code is latched into IC13 (a 74LS175 quad D flip-flop) and applied to the rate multiplier. The 4-bit combination (corresponding to a hexadecimal value of 0 to F loaded into IC13) selects one of 16 clock rates that range from 614.4 kHz to 902.4 kHz in 19.2-kHz increments. The frequency change of near 20 kHz creates a relatively small pitch change by itself (out of a 720-kHz nominal input frequency), but, used dynamically in a sentence, it is just what the doctor ordered for syllable inflection.

Remember that the 2 manual-inflection bits are still available to the user; they are set by 2 bits on IC11 ($\overline{SEL3}$). I refer to the level set by these bits as the "base pitch" and the 16 frequencies from the rate multiplier as the "clock rate." The combination of the 2 functions results in 64 pitch levels or inflections.



The pitch at which individual phonemes are pronounced may be controlled automatically by the text-to-speech algorithm, kept fixed, or altered by user command. Some people prefer automatic inflection, because of the variety it gives to the speech. Others think a computer should sound like a computer and prefer flat speech to artificially intoned speech. Still others may wish to directly control the pitch to make the unit sing (pitch and rate codes may be mixed with phoneme codes to produce singing) or to pronounce words with special emphasis.

The user may control the base pitch setting independently of the clock rate by issuing a pitch-control command:

!P*x*

where x is a digit from 1 through 4; $x=1$ selects the lowest pitch with pitch increasing according to the value of x.

The user may also control the clock rate with a command of the form

!R*y*

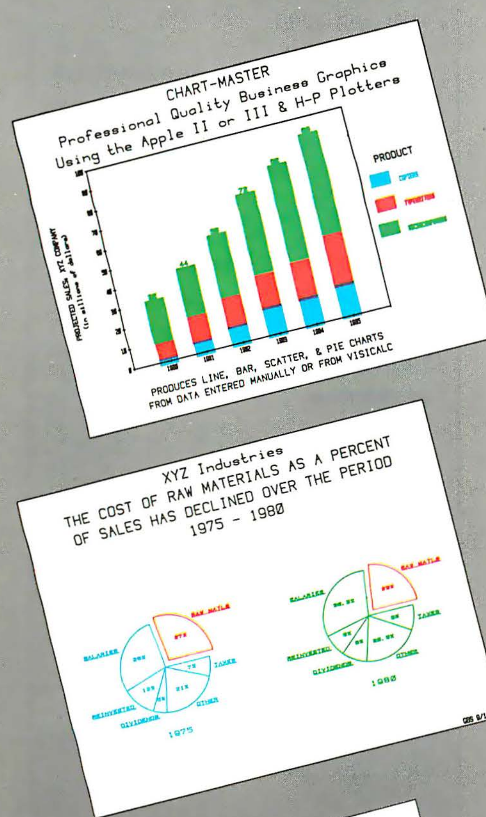
where y can take on values from 1 to 16; $y=1$ selects the lowest pitch; $y=16$ the highest.

Musical Abilities

One final feature of the Microvox is the ability to play musical notes and produce sound effects by using a program routine to toggle one bit of the PIA (IC11) at a predetermined rate. This line is connected to the output audio amplifier along with the output from the speech synthesizer

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(6) STORE/RETRIEVE/DELETE CHART
(7) MISCELLANEOUS
(8) QUIT
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chip (IC12). The results are similar to the sound produced by the internal speaker of an Apple II computer using the same technique.

While the Microvox is not exactly a virtuoso instrument, programming it to play a simple tune is not hard at all. The music mode is turned on by the command:

!N

Once the music mode has been activated, a different set of note-specifying commands is used.

In the music mode, notes may be chosen from a range of 3 octaves centered on middle C, indicated by numbers from 1 to 3. Each octave contains notes identified as A, B, C, D, E, F, or G. Sharps are indicated by the suffix character "+", flats by "−". Time values are selected by reciprocal numeric arguments: the length of a note may vary from a whole note (length of 1) to a 128th note (length of 128). Rests are indicated by "R". When in the music mode, sending Microvox the character string "3F+4" causes it to play a quarter note at a pitch of F sharp in the third octave. "R16" causes a sixteenth-note rest.

Notes of unconventional lengths may be used; for instance, the software supports "thirty-seventh" notes. Tempo may set from values of 50 to 128 beats per minute by a command of the type "T*x*" with *x* in the proper range. The default tempo is 80.

To Be Continued . . .

I apologize if I am jumping ahead too quickly. It's just that I want you to be assured that these hardware features of music and programmable pitch are not an overcomplication; they are easily accommodated in the software.

Obviously, there is no conclusion this month. I'll have a lot more to say next month. And keep in mind that while the main object of this project is an easy-to-use text-to-speech synthesizer, the computer section of the circuit has some special merit of its own. You may expect to see the same 6502-based control-computer design in future Circuit Cellar projects.

Next Month:

We'll take a look at the software and operation of the Microvox speech synthesizer. ■

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To receive a complete list of Ciarcia's Circuit Cellar project kits available from the Micromint, circle 100 on the reader service inquiry card at the back of the magazine.

The following are available from:

Intex Micro Systems Corporation
Suite 717
755 West Big Beaver Road
Troy, MI 48084
(313) 362-4280

1. Intex-Talker, the assembled, tested, and FCC-approved version of the Microvox text-to-speech synthesizer. With power supply and documentation........$295. OEM pricing and availability will be discussed on request. Michigan residents please include 4 percent sales tax. Please include $4 for shipping. Overseas orders add $20 for shipping.




The Micromint Inc.
917 Midway
Woodmere, NY 11598
(516) 374-6793
(for technical information)
(800) 645-3479
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2. Votrax SC-01A voice-synthesizer chip. . . . $70 each. Call for OEM pricing and availability.

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Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, 70 Main St., Peterborough, NH 03458.* Ciarcia's Circuit Cellar, Volume I, *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II, *contains articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III, *contains the articles that were published from July 1980 through December 1981.*

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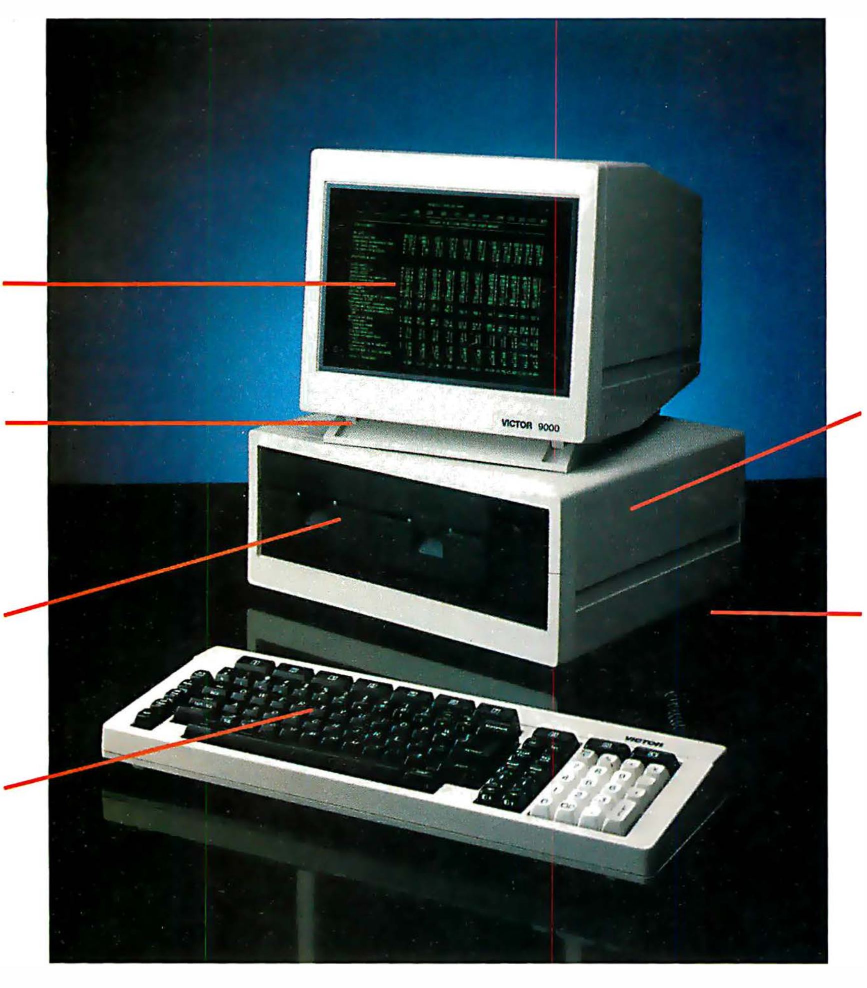
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Circle 479 on Inquiry card.



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In Canada: Digital Equipment of Canada, Ltd.



Circle 159 on inquiry card.

The Apple III and Its New Profile

An in-depth look at the "new" Apple III microcomputer and its Profile hard disk.

Robin Moore
Warner Hill Rd. RFD #5
Derry, NH 03038

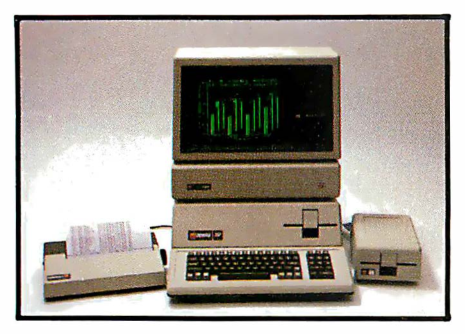


Photo 1: *A view of the Apple III, the Profile hard-disk drive, and the Monitor III showing a sample of Visicalc III on the screen.*

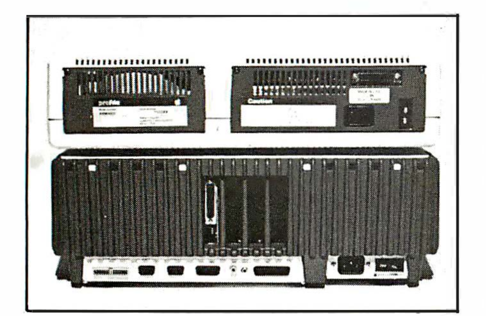


Photo 2: *A rear view of the Apple III and Profile showing the Silentype and game paddle ports A and B, along with the video, audio, RS-232C, and floppy-disk connectors. The peripheral card visible is the Profile interface card.*

In 1980 when the Apple III was first released, there were problems. Deliveries were delayed, and when the machines finally arrived, they often didn't work. The integrated circuits tended to wander out of their sockets. Little software except Visicalc was available, and the much-promoted real-time clock/calendar didn't work well. The Apple III was, on the whole, unreliable. It was a bad start.

Now, in 1982, the problems are gone. The sockets have been changed and the software bugs fixed. The Apple III has been rereleased with revised software, Pascal, and a brand-new peripheral—the Profile, a 5-megabyte hard-disk drive. The new Apple III is an impressive machine and certainly a contender for the title of Best Personal Computer in the less than $10,000 class.

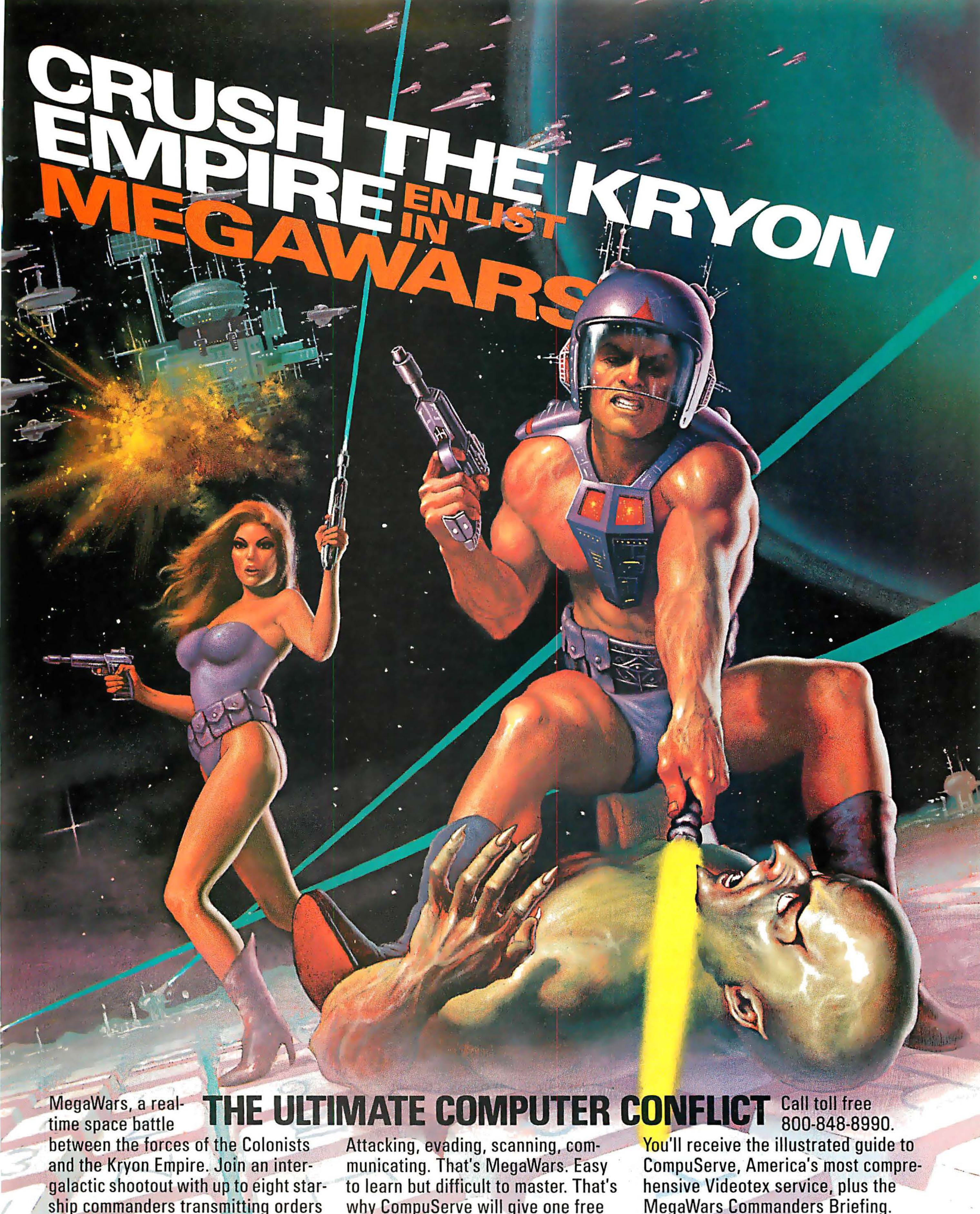
System Overview

Let's take a closer look. The Apple III is a single unit that includes the central processing unit, keyboard, memory, floppy-disk drive, and video output (see photos 1 and 2). It has been designed to meet the needs of the professional or small-business user. Instead of offering an initial low-cost unit requiring a number of additions, Apple Computer Inc. has included the most common system expansions as standard in the Apple III. These include an enhanced keyboard, a 24-row by 80-column display, an integral disk drive, 128K bytes of memory, a programmable 128-character set, improved high-resolution graphics, and an Apple II emulation program (see the At a Glance box for additional features and details).

In addition, several peripherals are available for the Apple III. The most impressive of these is the Profile, Apple's new 5-megabyte hard-disk drive. (The Profile will be described in detail later in this article.) Other options from Apple Computer in-

About the Author

Robin Moore is manager of microprocessor development for A. B. Dick Co. and maintains a strong interest in FORTH, graphics, and computer music. He is also librarian for the Southern New Hampshire Apple Core.



Circle 102 on inquiry card.

At a Glance

Name
The Apple III Computer

Manufacturer
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Components
System Unit

Size:	width 17.5 inches (44.45 cm), depth 18.2 inches (46.23 cm), height 4.8 inches (12.19 cm)
Weight:	26 pounds (11.8 kg)
Power Required:	107–132 volts AC, 60 Hz, 100 watts maximum
Processor:	6502B (2 MHz) with bank switching and enchanced indirect addressing, double stack and zero pages
Memory:	128K bytes of dynamic RAM (expandable to 256K bytes), 4K bytes of self-test and boot-loader ROM
Standard:	keyboard for text and data entry; programmable RS-232C serial communications/printer interface; power-up self-check and disk bootstrap; both color-graphics and black-and-white/gray-scale graphics video outputs; two game-paddle/joystick connectors; three audio generators—fixed beep, 1-bit programmable, and 6-bit A-D converter; one 140K-byte 5¼-inch floppy-disk drive
Video Display:	Three Text Modes 24 by 80, black and white, normal and inverse 24 by 40, black and white, normal and inverse 24 by 40, 16 color characters on 16 color backgrounds All text modes have software-definable 128-character sets Four Graphics Modes 280 by 192, 16-color foreground and background with limitations 280 by 192, black and white 140 by 192, 16 colors with no limitations 560 by 192, black and white
Video Outputs:	Both black-and-white/gray-scale and color-graphics outputs providing NTSC monochrome composite video, NTSC color composite video, or 4-bit coded RGB color with a separate composite synchronization signal
Keyboard:	74 keys for text and data entry; includes 13-key numeric pad for fast numeric entries, four cursor control keys with two-speed auto-repeat, three special-function keys, and text keys that allow entry of all 128 ASCII characters; SOS software provides a 128-character type-ahead keyboard buffer; all keys automatically repeat after ½ second
Disk Drives:	System supports up to four 140K-byte 5¼-inch floppy-disk drives using Apple-format 6/8 GCR (group-coded recording) encoding

Operating System
Apple III SOS 1.1 (Sophisticated Operating System); single task, interrupt-driven, configurable operating system with hierarchical file structure, multiple file protection levels, and device-independent byte-oriented I/O

Special Features
An Apple II emulation mode that allows use of almost all existing Apple II software; utilities that allow transfer of DOS text files, Visicalc files, and Pascal files from the Apple II to the Apple III

Software Available for the Apple III
Visicalc III $250; Applewriter III $225; Apple III Pascal $250; Business BASIC $125; Apple Access III (communications software) $150; Apple III Business Graphics $175; Pascal Utility Library $75; Script III $125; Mail List Manager $150; all from Apple Computer Inc.

Hardware Prices (Apple Computer Inc)

Apple III 128K-byte system	$3495
Apple III 256K-byte system	$4295
Additional disk drives (three maximum)	$495
Profile 5-megabyte Winchester hard disk-drive and interface card	$3,499
Universal parallel interface card	$225
Apple Monitor III (monochrome/green screen)	$320
Game controllers	$29.95

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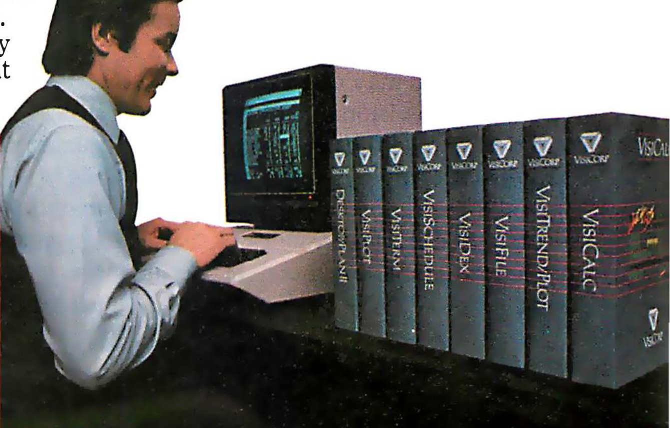
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Apple III (list prices)	
128K-byte system unit with integral 140K-byte 5¼-inch floppy-disk drive, Apple SOS operating system software, both color-graphics and black-and-white/gray-scale video outputs, RS-232C serial interface, game control port, and Silentype printer interface	$3495
additional floppy-disk drive (three maximum)	$495
Apple Business BASIC software	$125
total	$4115
IBM Personal Computer (suggested retail prices)	
48K-byte system unit, disk-adapter card, one 160K-byte floppy-disk drive, DOS software, Disk BASIC	$2235
16K bytes of added memory and game adapter card	$145
additional floppy-disk drive (one maximum)	$570
serial RS-232C interface card	$150
additional 64K-byte memory card	$540
color-graphics video adapter card	$300
Microsoft extended BASIC software	$40
total	$3980

Table 1: *Price comparison of comparable versions of the Apple III and the IBM Personal Computer. Both systems include 128K bytes of memory, two floppy-disk drives, color-graphics video output, serial RS-232C interfaces for Qume (or equivalent) letter-quality printers, and game-paddle adapters. The system chosen is one that might be purchased by people who wish to combine business and personal applications. Note that in this configuration the IBM has used up all its expansion slots, while the Apple III still has all four of its slots left for further expansion.*

clude the Silentype thermal printer, additional floppy-disk drives, the monochrome green-screen Monitor III, a universal parallel I/O (input/output) interface card, and game controllers.

Many of the existing Apple II interface cards will work in an Apple III while in the Apple II emulation mode. However, use of Apple II cards in an Apple III will probably make it exceed FCC (Federal Communications Commission) radio-frequency radiation limits and may cause interference on nearby television sets or radios. In addition, Apple II cards are not compatible with Apple III software unless special *device-driver* routines are written, and Apple provides virtually no information on how to write them.

Apple Computer currently provides a variety of software packages for the Apple III in addition to Business BASIC and Apple Pascal. There are also various hardware and software products available for the Apple III from other vendors and the number of these will increase as the Apple III user community grows.

The only software built into the Apple III is a 4K-byte ROM (read-only memory) that holds power-up self-test and disk bootstrap routines. All other software is loaded from disk. Although this means that languages use up some of the available RAM (random-access read/write memory), it also allows easy software upgrades and fixes that would be more difficult if the software were permanently in ROM.

System Pricing

The approach to Apple III pricing is almost directly opposed to the pricing strategy used for the Apple II and the IBM Personal Computer. Because Apple chose to include a large number of standard features, the Apple III has a relatively high initial cost ($3495); however, it can expand to 256K bytes of memory, four floppy-disk drives, and a letter-quality Qume (or equivalent) printer without using *any* of the expansion slots. A fully usable system can be configured by adding just a video monitor and an inexpensive serial printer.

Table 1 shows a price comparison of the Apple III and the IBM Personal Computer. Both systems are configured with 128K bytes of memory, two floppy-disk drives, a serial RS-232C printer interface, color-graphics video outputs, and game controllers. The IBM system costs slightly less but uses all of its expansion slots, while the Apple III still has its four slots available for future growth.

The Apple III User

A look at the documentation and software supplied with the system will quickly reveal that the Apple III is targeted for professional and small-business users. Clear tutorials and example programs on disk demonstrate most system functions and features. There is even a two-disk program to lead you through the keyboard and display functions step by step.

The Apple III is not designed for the home hobbyist. Much of the technical information included with the Apple II is absent in the Apple III package. There is no discussion of bus structure, I/O addressing, memory usage, or screen-memory mapping. There are no listings published for any of the system software, either in the Apple III ROMs or on disk. Apple does not even tell you about the monitor program included in the ROMs (which is accessible by holding the Control and Open-Apple keys while pressing Reset).

All this technical information is unimportant to business users. They are more interested in *using* the Apple

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Photo 3: *The Apple III with its main cover removed. The power supply is housed in the enclosure visible to the left, I/O card slots are in the center, and the disk drive is on the right. The entire Apple III is built around a single thin-wall aluminum casting that provides both support and shielding.*

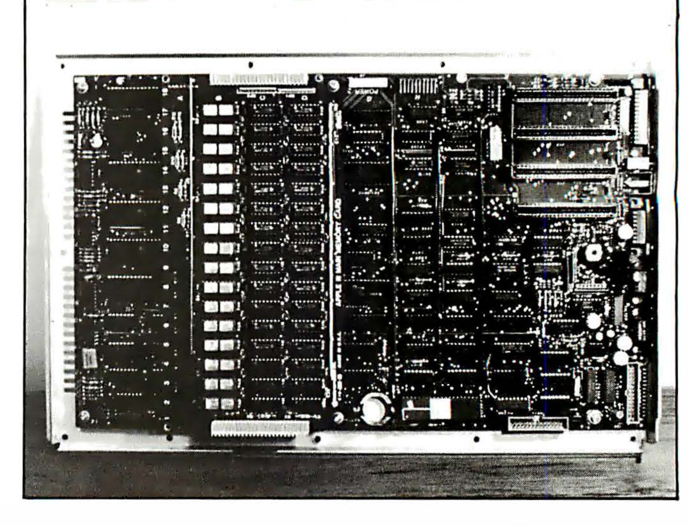


Photo 4: *The Apple III main PC board. The piggy-back-mounted board to the left of center is the removable main memory board. Using this board, the Apple II can be expanded to its full memory capacity without using up any of its I/O expansion slots.*

III than in dissecting it, and will, in most cases, use commerical software. The Apple III is admirably designed to serve their needs. For hobbyists there are better choices, namely, the Apple II.

Inside the Enclosure

The Apple III is a fine example of a quality product designed for high-volume production. The entire unit is built around a single thin-wall aluminum casting that provides support and shielding as well as heat dissipation so that no cooling fan is required. The expansion card guides are molded into the casting, and fully enclosed boxes are built in for both the main printed-circuit (PC) card and the switching power supply (see photo 3).

All of the circuitry, except memory, is on one main PC board (see photo 4). The system memory board mounts piggy-back style onto the main board and avoids taking an expansion slot. In fact, the Apple III can be expanded to its full 256K-byte memory capacity in the same fashion, leaving all slots free.

The Apple III central processing unit is based on a 6502B microprocessor with custom external circuitry that provides a number of enhancements to the normal 6502 instruction set. These enhancements include expanded addressing range, alternate stack and zero pages, and improved indirect addressing that is supported by a separate pointer page.

Although the technical information provided by Apple is somewhat vague, apparently the 6502B is run at 2 MHz during the video blanking intervals and at 1 MHz while the beam is writing information onto your monitor screen. This provides an average speed of about 1.4 MHz, but the screen can be turned off temporarily during program execution to allow the processor to run at its full 2-MHz speed, if desired.

The Apple III can be configured to 256K bytes without using a single expansion slot.

While a normal 6502B can address a maximum of 64K bytes of memory, the Apple III uses bank switching to expand this range to a theoretical maximum of 512K bytes.

Up to fifteen 32K-byte blocks of memory can be switched to occupy the range of addresses between 2000 and 9FFF hexadecimal. This switching is handled automatically by the operating system and is totally "transparent"; that is, the switching executes in the background without affecting any task you may be performing in the visible foreground. It should be noted that, to date, Apple Computer has not announced any Apple III memory expansion beyond 256K bytes. Perhaps this will be a future option.

The main PC board also includes the disk controller, serial interface, video generation circuitry, and the expansion card slots. The expansion-bus connections in the Apple III are essentially the same as those in the Apple II, although DMA (direct memory access) is handled somwhat differently. The Apple III *Owners Manual* provides no information about the expansion bus. Hopefully, this type of information will be available in the future. There are few competing systems that do not make this sort of information available to the public.

The Keyboard

Experienced typists should find the Apple III keyboard easy to use (see photo 5). Unlike the Apple II, this keyboard has a typewriter layout so that touch-typists should feel comfor-

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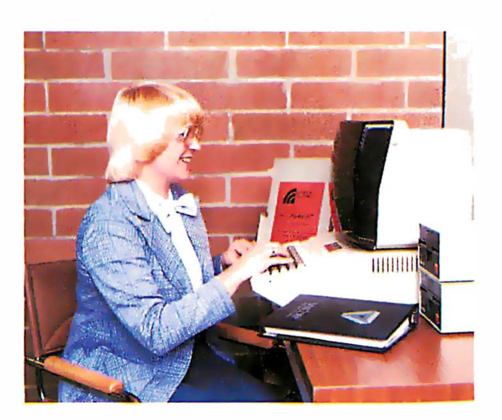
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The popular language software for the portable computer includes Extended Basic Compiler/Interpreter, SnapFORTH and Microsoft Basic.®

The Panasonic portable computer also has a wide range of specific software programs for your specific problems, such as:

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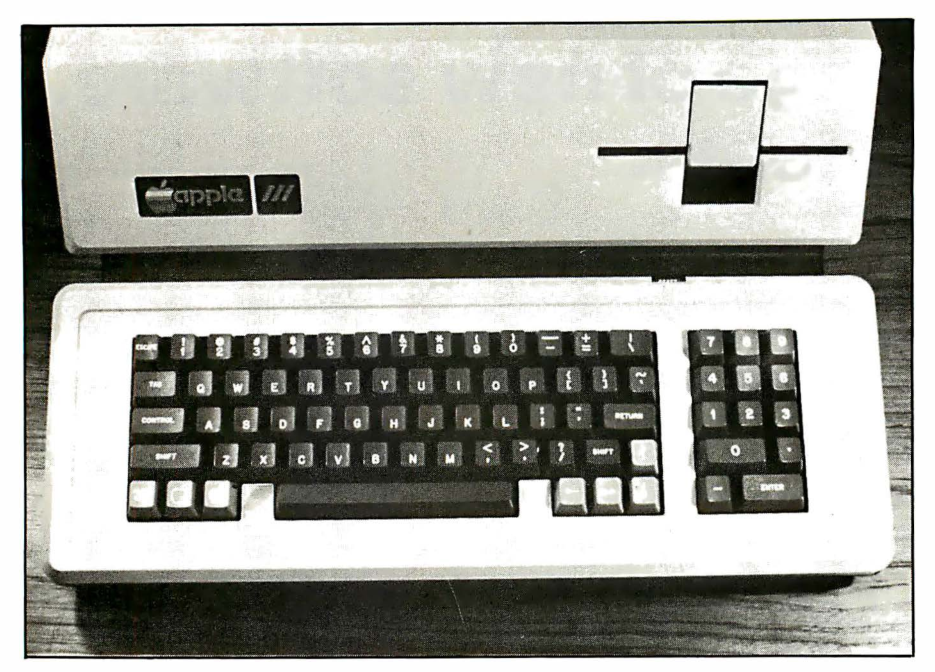


Photo 5: *The Apple III keyboard. Although it looks separate, it is actually part of the Apple III main enclosure.*

table with the key placement. The layout of the numeric keypad on the right, which resembles that of a calculator, allows easy entry of numeric data. The Apple III can also generate all 128 ASCII (American Standard Code for Information Interchange) codes without extra hardware.

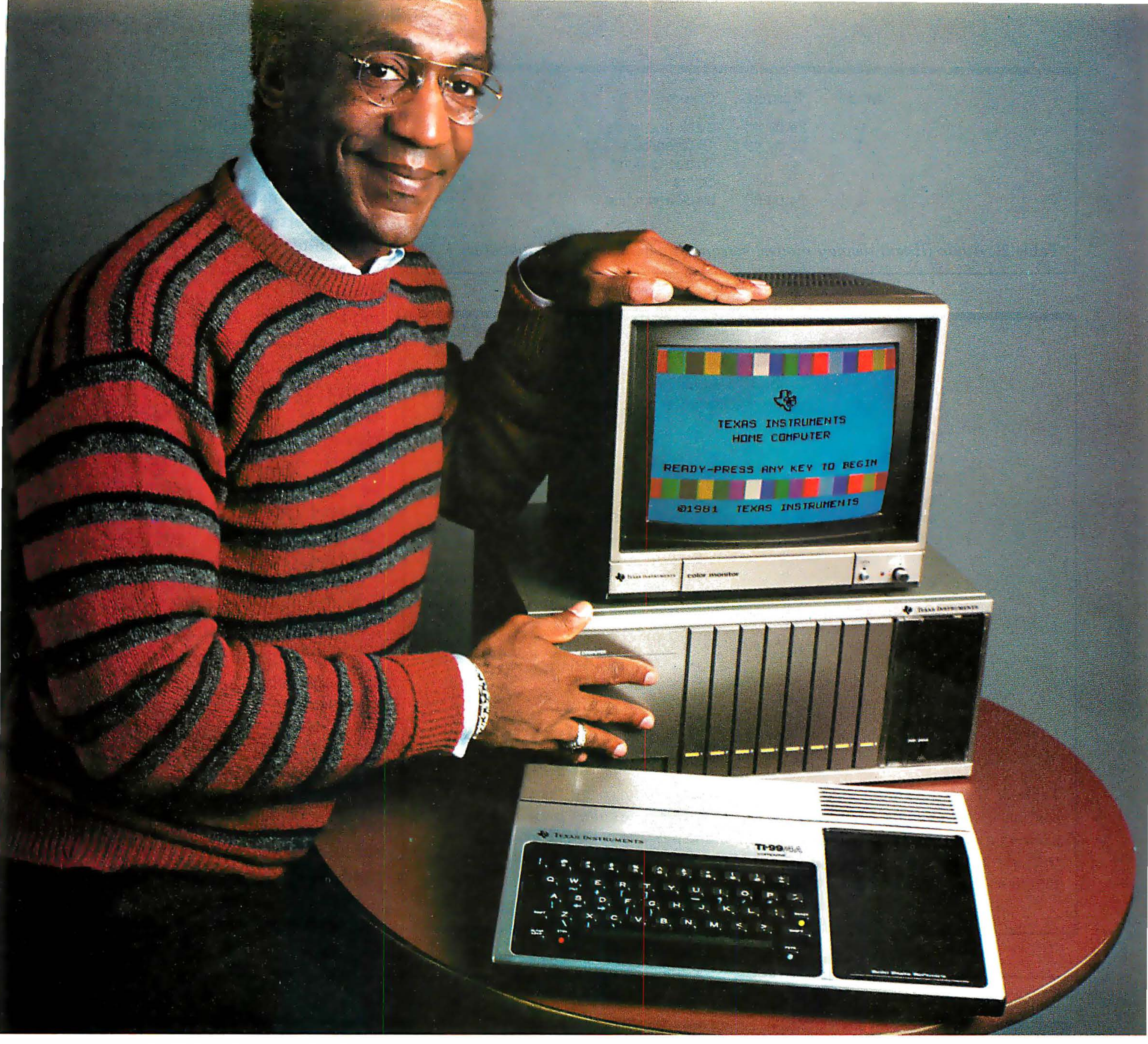
In addition to the normal Shift, Control, and Caps-Lock modifier keys, the Apple III includes special Open-Apple and Close-Apple keys that you can define for special functions. All keys automatically repeat when pressed for more than ½ second, and the four cursor-movement keys each provide a 2-speed repeat—pressing gently repeats at 11 Hz, while pressing firmly repeats at 33 Hz.

Apple's SOS 1.1 operating system provides a 128-character type-ahead buffer so that keystrokes won't be lost if you continue to type while the system is busy. This buffer may be emptied, or flushed, if the program running needs to wait for a particular keystroke.

One of the biggest complaints about the original Apple II concerned the close proximity of the Reset key to the rest of the keyboard. In the Apple III the Reset key has been positioned at the rear edge of the keyboard enclosure, thus avoiding the accidental resets encountered in early Apple IIs. Simultaneously pressing Control and Reset simulates a power-up and reboots the system from the main disk drive.

In addition to the normal keyboard functions, a number of special control features are built into the Apple III keyboard. Pressing the Control key and one of the keys on the numeric pad will allow you to turn the video on and off, flush the type-ahead buffer, suspend screen output so that the processor can run at maximum speed, display control characters, or turn off the screen until the program requests an input.

In general, I found the keyboard versatile and pleasant to use. (Although the keyboard is actually part of the main enclosure, it is styled to appear as a separate unit. A convenient recess at the top can support a book or a pencil.) My only problem was that the very light touch required to avoid automatic key repeat sometimes caused me to produce extra characters. You have to break the habit of letting your hands rest on the keyboard while thinking about what to type next.



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TEXAS INSTRUMENTS

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Mode	Format	Colors
0	24 by 40	black and white
1	24 by 40	16 foreground and 16 background colors
2	24 by 80	black and white

Table 2: *Apple III text display modes, screen formats, and color capabilities.*

Color	Color Value	ASCII Character	Gray Level
black	0	0	black
magenta	1	1	
dark blue	2	2	
lavender	3	3	
dark green	4	4	dark gray
gray	5	5	
medium blue	6	6	
light blue	7	7	
brown	8	8	medium gray
orange	9	9	
gray 2	10	:	
pink	11	;	
green	12	<	light gray
yellow	13	=	
aqua	14	>	
white	15	?	white

Table 3: *Table of graphics colors or gray levels produced by the GRAFIX driver routine. After opening the routine as an output device, colors may be selected by printing a CHR$(9) followed by an ASCII character. The color values shown are extracted from the lower four bits of the ASCII code transmitted. Higher-level graphics functions are provided by the BGRAF invocable module.*

Display Modes

The Apple III offers several text and graphics display modes. Either type of display is available in black and white or color, and both offer various formats and resolutions.

The normal text display is black and white, with a 24-row by 80-column format and a maximum of 1920 displayed characters. Alternate modes include 24 by 40 black and white and 24 by 40 color. In all three text modes the characters are normally displayed as a 5- by 7-dot matrix within a 7- by 8-dot character cell. However, all 128 characters are user-programmable and may be defined to be 7 dots wide by 8 dots high so that adjacent characters will touch in all directions if desired. (See table 2 for available text display modes.)

In the 40-column color-text mode, you can display 16 colors of characters on 16 colors of background. In combination with the user-definable character set, you can produce some surprisingly good color-graphics displays. For example, Apple's well-known "running-horse" demonstration program (shown in photo 6) is produced in color-text mode. The color values shown in table 3, although specified for graphics, can also be used for color text.

With four graphics modes, the Apple III's capabilities are significant-

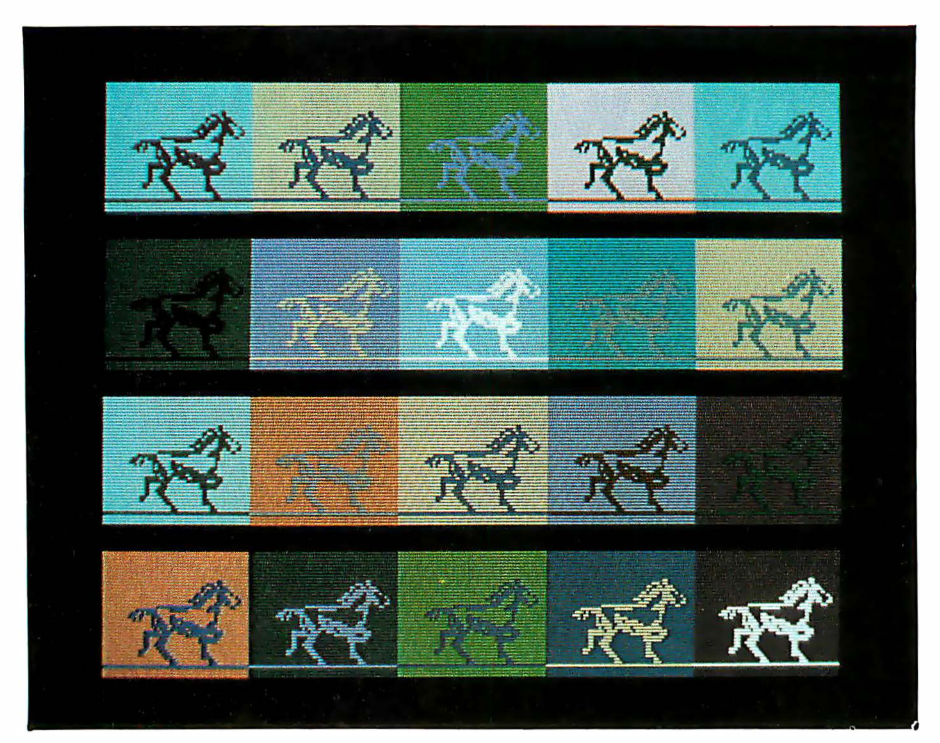


Photo 6: *The well-known "running horse" demonstration. This display was generated using the 24-row by 80-column color-text display mode using the Apple III's programmable character set to produce the special shapes required.*

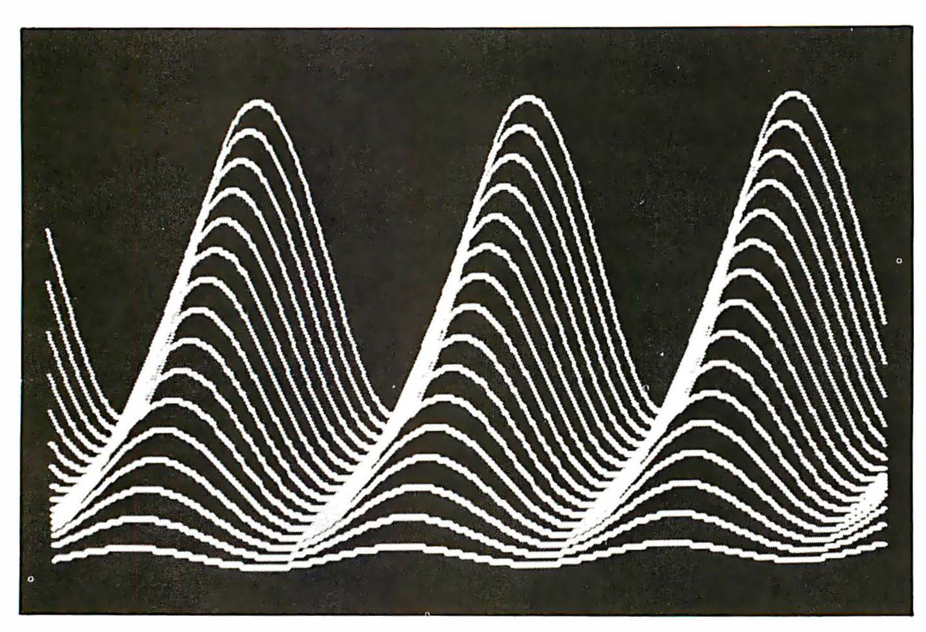


Photo 7: *An example of the 560- by 192-pixel graphics display mode. Although this mode doesn't offer color, it is ideal for displays that require fine detail.*

ly better than those of the Apple II (table 4 shows the available modes). The highest resolution offered is 560 by 192 pixels, black and white. This mode is useful for scientific or technical displays that require maximum resolution, as shown in photo 7. There is also a 280 by 192 black-and-white display mode.

The highest-resolution color display available is 280 by 192 pixels. Using this mode you can display up to 16 colors with some limitations. In each 7-dot-wide section of a given vertical coordinate, only two colors can be displayed. Bits that are turned on will display the specified foreground color, while bits that are turned off display the background color for that section. This is usually noticed only when lines of different colors cross. The limited color mode is useful for many applications where 16 colors are required but where maximum resolution is needed (an example is shown in photo 8).

The most colorful graphics mode is the 140- by 192-pixel 16-color mode. With no limitations on color placement, it is capable of producing very impressive displays (see photo 9). One of the more interesting techniques in this mode mixes various colors of dots to produce a variety of in-between shades of color. Using this technique, it is possible to produce several hundred colors on an Apple III.

Although the resolution is effectively reduced in the shaded areas, this method is typically used for filling in areas of pictures rather than for outlines, which are normally drawn in solid color. A talented artist with a digitizing tablet and the appropriate software can produce results like those shown in photo 10.

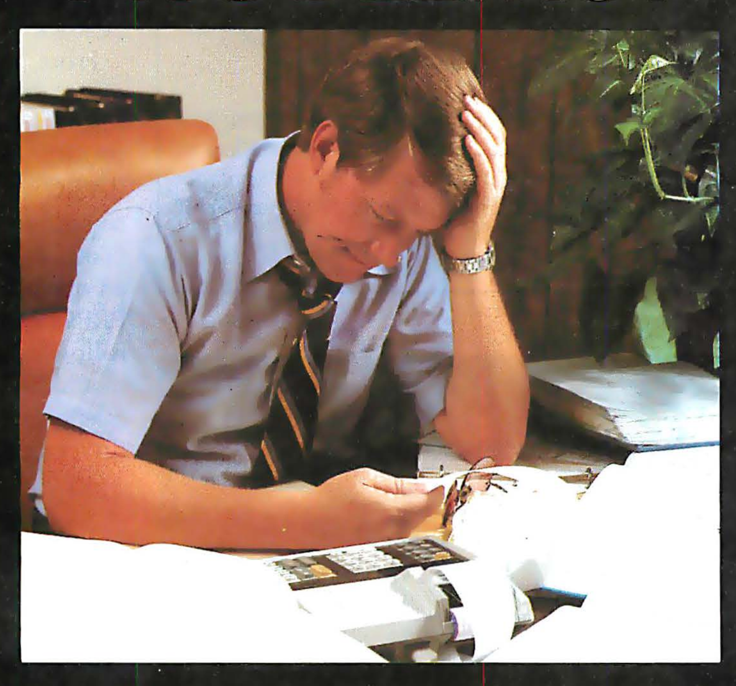
Apple SOS

Apple's SOS (Sophisticated Operating System) 1.1 is one of the more powerful operating systems available for an 8-bit microcomputer and offers features usually found only on larger machines. SOS supports multiple nested directories, handles interrupt-driven and DMA I/O, and manages the Apple III memory and hardware environment.

A unique feature of SOS is that there is no user interface. All communications with SOS are handled by the resident language (BASIC or Pascal for now) in a fashion compatible with the language syntax. For example, with Business BASIC you display a disk directory by typing CATALOG (or CAT), but in Pascal you would press F to enter the filer and then press E to get an extended directory. Rumor has it that Apple is working on a separate SOS user-interface package. This would allow access to SOS without requiring that a language be loaded into the system.

All Apple III I/O is handled by SOS through device drivers. Each

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Graphics Mode Main Screen	Alternate Screen	Graphics Resolution	Colors Available	Memory Used
0	4	280h by 192v	black and white	8K
1	5	280h by 192v	16 colors with limitations	16K
2	6	560h by 192v	black and white	16K
3	7	140h by 192v	16 colors, no limitations	16K

Table 4: *The Apple III graphics modes, resolution, available colors, and graphics screen memory requirements. Each main mode allows two separate screen buffers so that one screen may be updated while the other screen is displayed. When the black-and-white gray-scale video output is used, the 16 colors are output as 16 gray levels from black to white.*

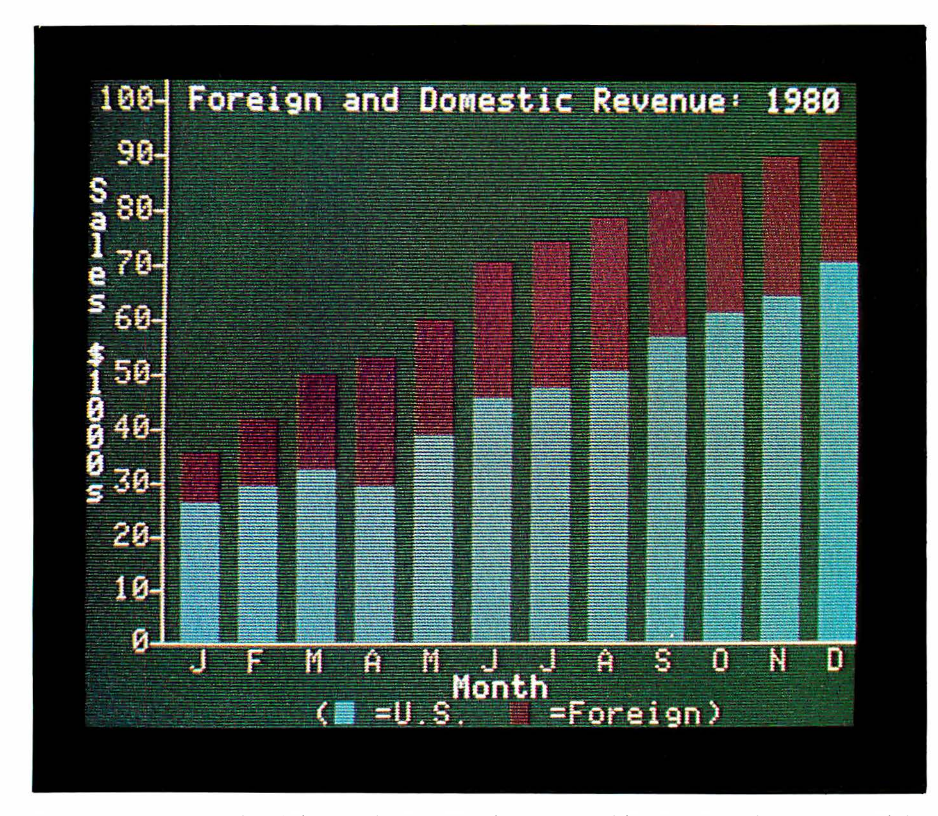


Photo 8: *An example of the Apple III's 280- by 192-pixel limited 16-color mode. While there are some limitations on the combinations of colors that can be displayed next to each other, this mode offers the highest color resolution and is useful in many applications.*

device driver is a group of routines designed to communicate with a particular hardware device and provide a uniform interface to SOS. For example, in a minimal Apple III system, you need the device driver .CONSOLE to handle the keyboard and text display, as well as .FMTD1 to handle the system floppy disk. Some of the other drivers included with the system are .AUDIO, .RS232, .PRINTER, and .GRAFIX. Even though the RS-232C interface and the graphics display hardware are included in the Apple III, they are considered optional I/O devices for programming purposes.

The System Configuration Program (SCP) provides a variety of tools that allow you to modify and reconfigure the system device drivers. Once the device drivers are specified, the SCP can regenerate a version of the system that meets your particular requirements. You can also use the SCP to specify whether a driver will be active or inactive. When the system is booted up, only the active drivers in the SOS.DRIVERS file will be loaded and require memory space.

From the programmer's point of view, device drivers are treated as files and can be used from either BASIC or Pascal. With Business BASIC they may be opened, accessed, and closed like any other file. (You can pass commands and data to an opened driver simply by using the PRINT# statement.) For example, the following Business BASIC lines would list the current program on the Silentype printer if the .SILENTYPE driver were installed:

```
10 OPEN#1, ".SILENTYPE"
20 OUTPUT#1
30 LIST
40 CLOSE#1
```

SOS allows the disk drives to be accessed either by their *device name* (e.g.,.D1) or by the *volume name* of the disk currently in the drive (e.g., MYDISK). Suppose that line 10 from the previous example were changed to read:

```
10 OPEN#1, "MYDISK/LISTFILE"
```

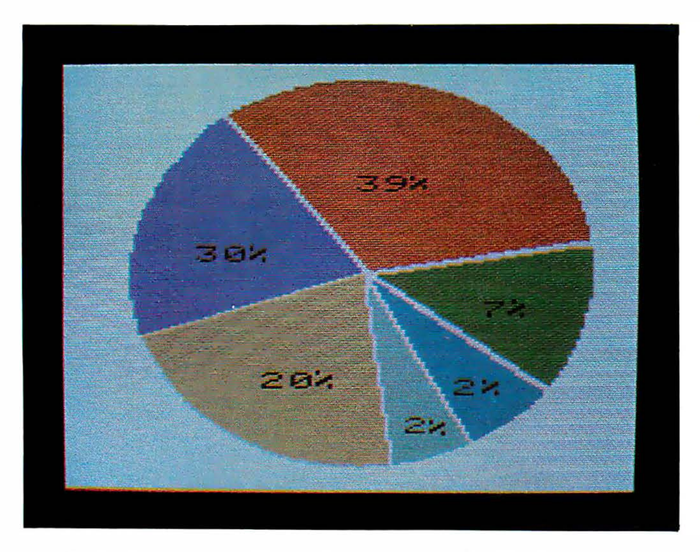
This would cause the program listing to be sent to a file called LISTFILE on a disk called MYDISK.

Unlike most systems which provide a single disk directory, SOS treats a directory like any other file. You can create and maintain directories easily with the same commands (LOCK, UNLOCK, RENAME, DELETE, etc.) that are used to maintain other files. You can assign any type of file to a directory, and any given directory may be a file assigned to another, higher-level directory.

The key to dealing with these nested levels of directories is the SOS *pathname*. Using device and file names separated by slashes, you can tell SOS what path to follow through various levels of directories. For example, the pathname /MYDISK/RECORDS/CHECKS/JAN.81/ would search the system for a disk volume



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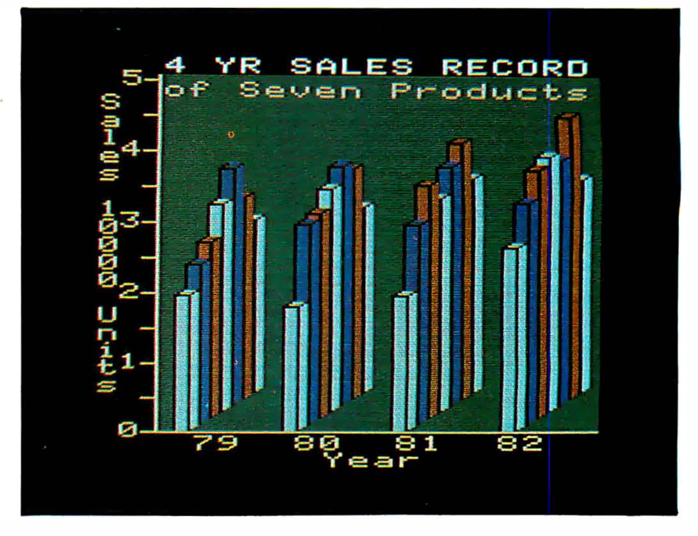


Photo 9: *Two examples of the 140- by 192-pixel full 16-color mode.*

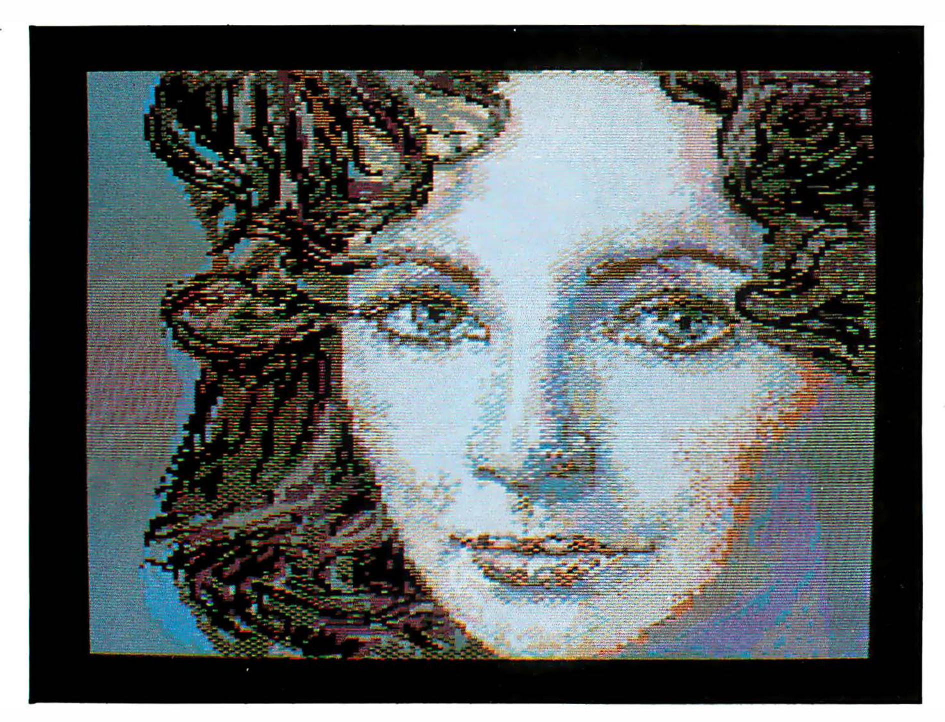


Photo 10: *A talented artist with a digitizing tablet and the appropriate software can produce results like this by using blended colors in the Apple III's 140- by 192-pixel color mode.*

named MYDISK, locate the directory RECORDS (which itself would contain the subdirectory CHECKS), and then locate the file JAN.81. The pathname specifies the sequence of directories to follow when accessing a given file. As a convenience, SOS provides a pathname prefix facility. By using PREFIX$ in the previous example, we could have set the pathname prefix to /MYDISK/RECORDS/ and then simply referred to CHECKS/JAN.81.

File types supported by SOS include DATA, which holds raw binary data; PASTXT (a Pascal text file); PASCODE (a machine language or Pascal program file); BASIC program files; ASCII files of unformatted text; PASDTA (Pascal data files); CAT or directory files; FONT files for the programmable character generator; and FOTO files, which store graphics screen images.

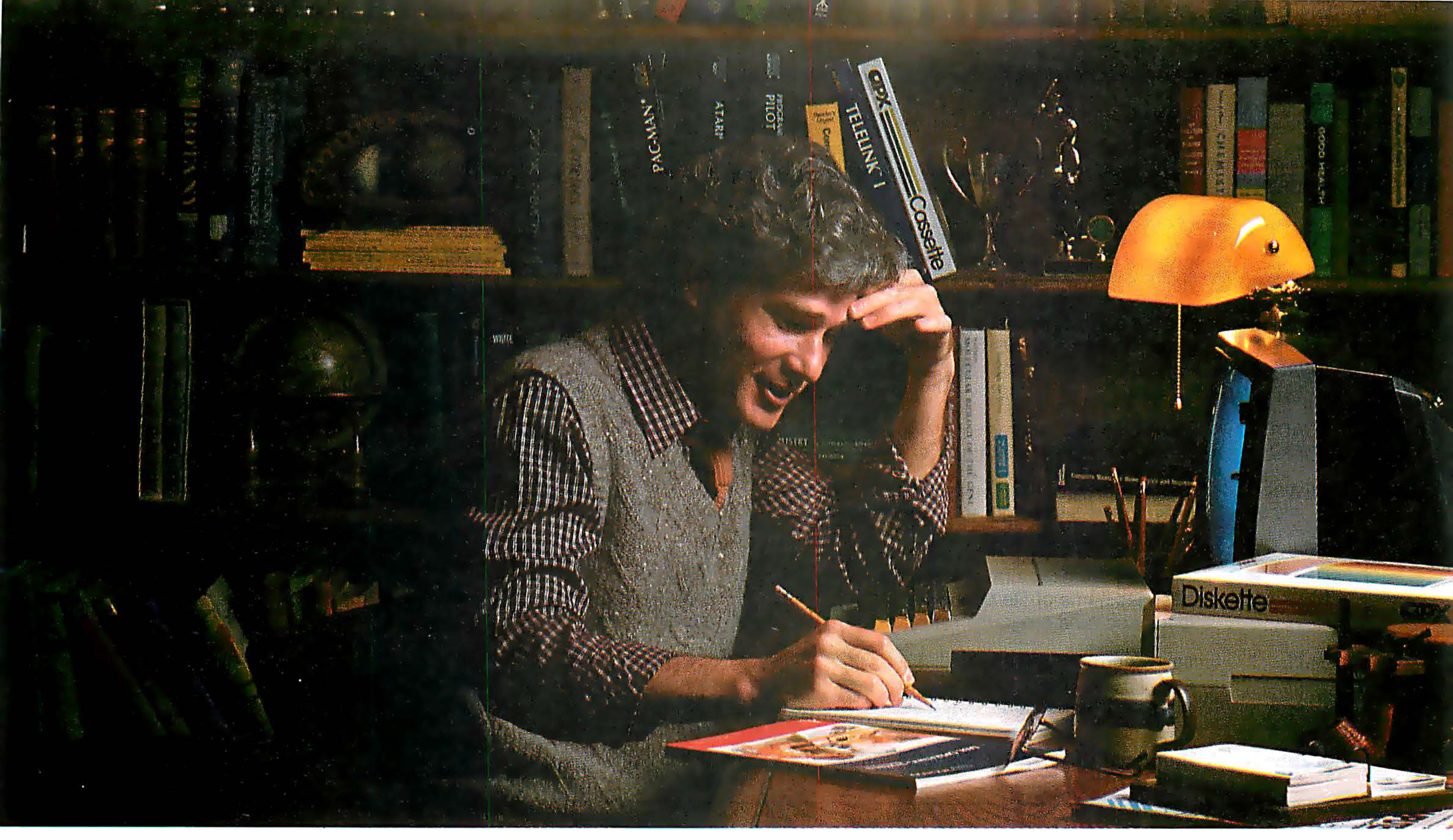
Business BASIC

Although it is fairly conventional, Apple's Business BASIC provides a combination of advanced and unique features that makes it an easier language to use than Applesoft BASIC. With Business BASIC you should be able to write shorter programs with fewer errors. (See tables 5a–5e for a summary of the language.)

Business BASIC supports both TEXT and DATA files. The commands PRINT# and INPUT# are used to access text files while READ# and WRITE# allow you to store or read any type of data in a DATA file. All files may be sequential or random access (with the record size defined when the file is created). You can also use the word CREATE to make new files and directories. Directory entries may be examined by reading sequential text records from a directory file.

The language also provides formatted I/O. To output data to either the screen or a file, you can specify the format with an IMAGE statement or within the PRINT USING statement. The Apple III's output formats are very flexible. Numbers may be printed in fixed-point, floating-point, scientific, or engineering formats. You can also align the right or left edges of the output to a particular column or center the output if you wish.

Four main data types are available in Business BASIC. You can use integers ranging from −32,768 to +32,767, real numbers with 6-digit precision, long-integers with 64-bit binary precision, or strings that can vary from 0 to 255 characters. Arrays



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Command	Description
CATALOG	lists a disk directory
CHAIN	executes a program from disk leaving variables intact
CLEAR	clears program variables
CONT	continues interrupted program
CREATE	creates a new file or directory on disk
DEL	deletes a specified range of BASIC lines
DELETE	deletes a file from disk
HOME	clears current text window and places cursor in upper left-hand corner
INVERSE	sets further text output to inverse video characters
LIST	lists BASIC lines
LOAD	loads a BASIC program
LOCK	protects a file from alterations
NEW	clears a program and variables from memory
NORMAL	sets further text output to noninverse video
NOTRACE	turns off trace option
UNLOCK	removes protection from a disk file
RENAME	changes name of file on disk
RUN	loads and runs programs from disk or runs current program
SAVE	saves current program on disk
TEXT	sets screen to text mode with full-screen window
TRACE	turns on trace option

Table 5a: *A summary of Business BASIC commands.*

Statement	Description
CLOSE	closes all open files
CLOSE#	closes a particular file
DATA	standard DATA statements
DEFD FN	user-defined function
DIM	dimensions arrays
END	ends program
FOR. . .NEXT	standard FOR loop
GET	reads a single character from the keyboard or an EXEC text file
GOSUB	executes a subroutine
GOTO	continues execution at a specified line
IF. . .GOTO. . .ELSE	modified IF statement
IF. . .THEN. . .ELSE	standard IF statement
IMAGE	defines a PRINT USING format
INPUT	reads data from the keyboard
INPUT#	reads text from a disk file or other open device
INVOKE	loads an external file module of assembly-language routines
ON EOF#	sets up end-of-file error trap
OFF EOF#	turns off end-of-file error trap
ON ERR	sets up general error trapping
OFF ERR	turns off general error trapping
ON KBD	sets up keyboard interrupt handling
OFF KBD	turns off keyboard interrupt handling
ON GOSUB	standard computed GOSUB statement
ON GOTO	standard computed GOTO statement
OPEN# . . . AS	opens a file as INPUT, OUTPUT, or EXTENSION
OUTPUT#	sends subsequent output to file
PERFORM	executes a previously invoked routine
POP	removes one level of subroutine nesting
PRINT	prints to current output device or file
PRINT USING	prints using a given format

Table 5b: *A summary of Business BASIC statements.*

Table 5b continued on page 114

without dimensional limits can be created out of all four data types. To convert between the various data types, Business BASIC provides the numeric functions CONV, CONV%, CONV&, and CONV$, all of which will accept arguments of any type and will produce real, integer, long-integer, and string results, respectively.

An interesting feature of Business BASIC is its use of *reserved variables* to access and control certain system functions (see table 5f for a summary). Reserved variable names are used to hold error codes, the file record numbers, or the code for the last key pressed. Others may be used to hold or control the cursor position on the screen, set the listing FOR. . .NEXT loop indent level, control the listing line length, or set the SOS pathname prefix.

One of Business BASIC's most powerful features is its ability to use *invocable modules*. An invocable module is a file of external procedures and functions, written in assembly language or Pascal, that can act as an extension to the BASIC language once invoked (loaded into the system). The modules provide features that are sometimes necessary but were not built into the Business BASIC language. The modules include VOLUMES.INV, which is used to show which volumes and devices are present in the system; READCRT.INV, which is used to read characters from the video display; DOWNLOAD.INV, which is used to load special text fonts into the Apple III's character generator; and RENUMBER.INV, which provides a variety of functions including program renumber, append, and merge. Another more significant module is BGRAF.INV which provides all the graphics procedures and functions used by Business BASIC.

Once a module has been invoked, the external procedures and functions provided in that file are accessed by using the BASIC commands PERFORM and EXFN. For example, the line

```
PERFORM PENCOLOR(%BLUE)
```

would execute the procedure to set

Table 5b continued:

Statement	Description
PRINT#	prints to a particular output device or file
PRINT# USING	prints to a particular file or device using a given format
READ	reads information from DATA statements
READ#	reads information from a data file
REM	standard remark statement
RESTORE	resets read pointer to start of DATA list
RESUME	returns from on ON ERR statement
RETURN	returns from a subroutine, ON KBD or ON EOF routine
SCALE	adjusts PRINT USING decimal-point position
SPC	used in PRINT statements to output numbers of blanks
STOP	stops program execution
SWAP	swaps the values of two given variables
TAB	used in PRINT statements to position the cursor to a particular column
WINDOW	sets the text/scroll window size and position
WRITE#	writes information to a data file

Function	Description
ABS	absolute value
ASC	converts ASCII character to its numeric value
ATAN	arc tangent
BUTTON	paddle-button state
CHR$	converts number to equivalent ASCII character
CONV	evaluates expression—returns real number value
CONV$	evaluates expression—returns string value
CONV&	evaluates expression—returns long-integer value
CONV%	evaluates expression—returns integer value
COS	cosine
EXFN	executes an invoked external function that returns a real number value
EXFN%	executes an invoked external function that returns an integer value
EXP	exponential, base *e*
HEX$	returns a string that represents the hexadecimal value of the expression
INSTR	searches a string for a substring and returns location of occurrence
INT	largest integer less than or equal to argument
LEFT$	takes substring starting with first character
LEN	length of a string
LOG	natural logarithm
MID$	extracts a substring from a given string
PDL	returns a game-paddle position
REC	returns current file record number
RIGHT$	takes substring ending with last character
RND	random number
SGN	sign of argument
SIN	sine
SQR	square root
STR$	converts a number to a string
SUB$	inserts a substring into a given string
TAN	tangent
TEN	converts last four characters of a string from a hexadecimal text image to a decimal value
TYP	returns the data type of a file record
VAL	converts a string to a numeric value

Table 5c: *A summary of Business BASIC functions.*

the graphic drawing color to blue, provided that the variable BLUE has previously been defined properly.

While external procedures may be passed only integer values, external functions can return either integer or floating-point numbers. The reserved word EXFN% is used to call functions that return integers and EXFN accesses functions that return real values.

BASIC Graphics

Although you could use graphics from BASIC by simply opening the .GRAFIX driver and sending characters directly to it, the BGRAF.INV module provides a much cleaner and more powerful interface. It essentially adds a number of graphics commands to the Business BASIC language. (A similar library unit is included with Apple III Pascal.) The .GRAFIX driver must still be present and opened because you need a controller for the graphics hardware, but all graphics operations are performed by the external procedures and functions provided by BGRAF. The following two lines provide all the setup required:

```
100 OPEN#1, ".GRAFIX"
110 INVOKE "BGRAF.INV"
```

BGRAF provides all of the standard graphics operations. You can set PENCOLOR and the background FILLCOLOR, plot dots at absolute or relative positions with DOTAT and DOTREL, draw lines to absolute or relative points with LINETO and LINEREL, and position the graphics cursor with MOVETO and MOVEREL. BGRAF supports a graphics VIEWPORT that allows you to limit graphics drawing to a particular area of the display screen.

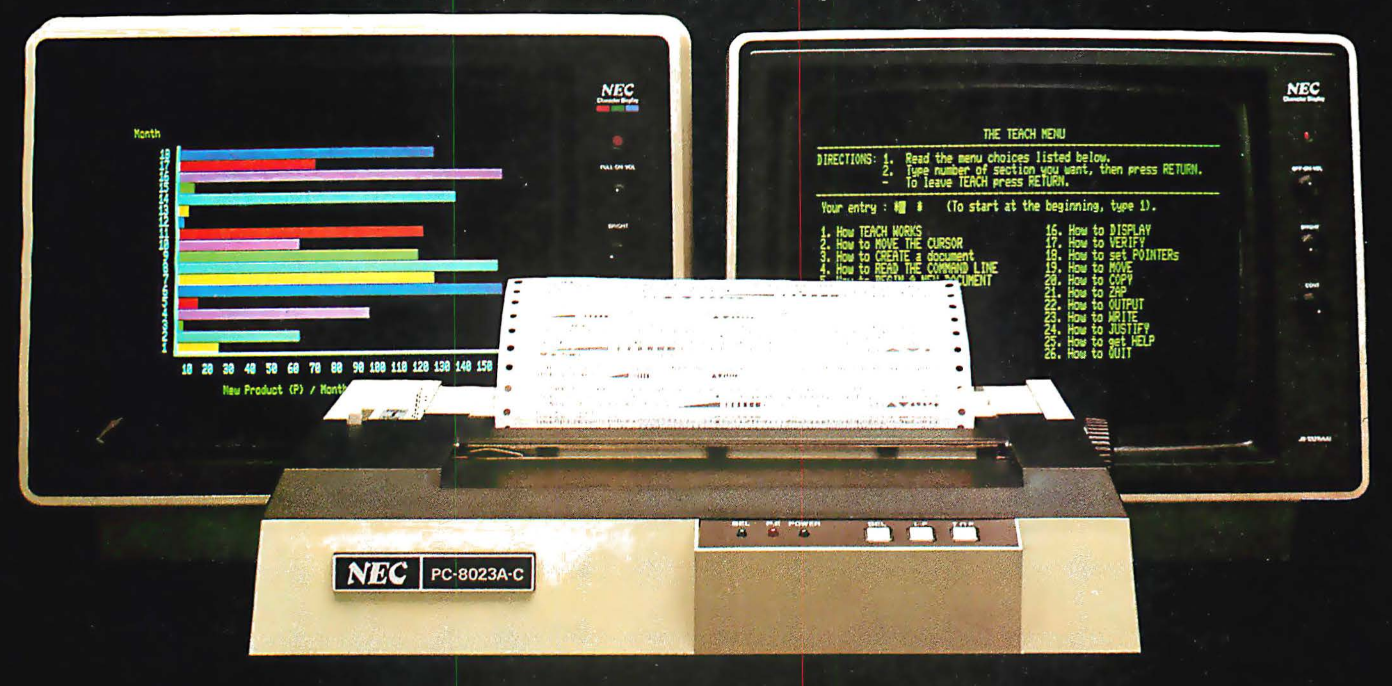
Text may be displayed with graphics by simply sending it to the opened .GRAFIX driver with a PRINT# statement. NEWFONT lets you redefine the graphics text font by specifying character form, height, and width. The SYSFONT command switches you back to the current text-mode display font.

Predefined images stored in integer arrays may be displayed with DRAWIMAGE. A given array may hold a

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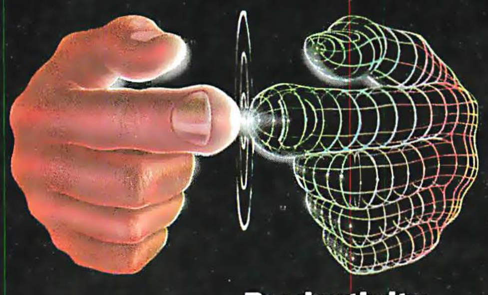


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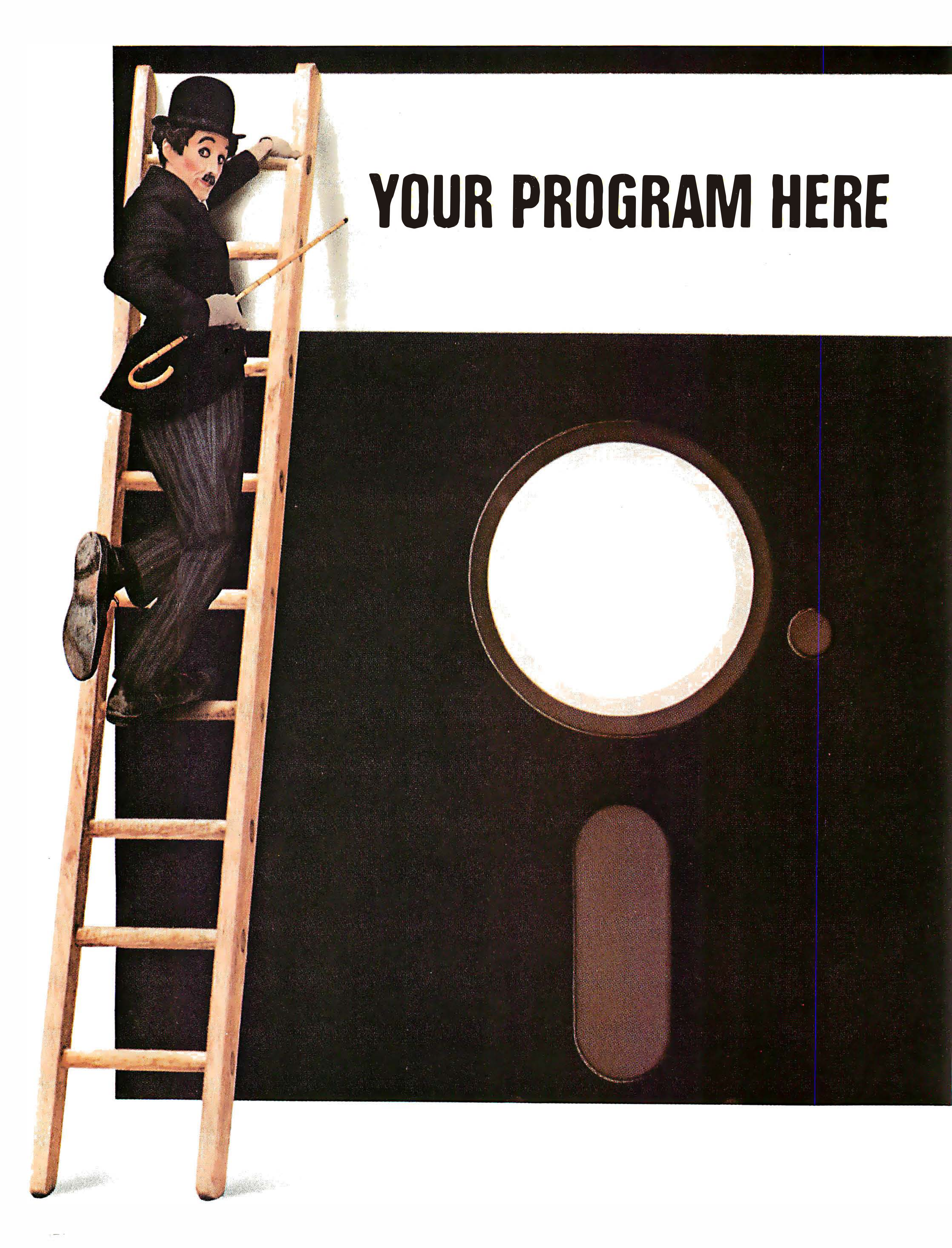
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Operators	Type
+ − * / DIV MOD	arithmetic
AND OR = < > >< <> <= =< >= =>	logical
NOT	unary logical
+	string concatenation

Table 5d: *A summary of Business BASIC data operators. DIV and MOD apply only to the long-integer data type.*

Data Type	Type Name	Range
16-bit integer	integer	−32768 to 32767
64-bit integer	long-integer	±9223372036854775807 ($\pm 2^{63} - 1$)
32-bit floating point	real	$\pm 10^{38}$ with 6 digit precision
character strings	string	0 – 255 characters
arrays	(all types)	no dimensional limits

Table 5e: *A summary of Business BASIC data types and ranges.*

number of images that can be selected with the DRAWIMAGE arguments.

One of the most interesting features of BGRAF is its control of color. By using two controllable processes—the color table and the transfer option—you can modify the effects of plotting and filling operations.

With 256 entries, the color table specifies which color results from plotting a dot of a given "source color" on top of a dot of a given "screen color." The color table is initialized to simply display the source color regardless of the existing color of the specified dot position. However, by altering the mapping conditions in the color table you can establish a color precedence. This precedence allows lines to appear to pass under or over existing images, or it can produce a number of other interesting effects.

To alter a color-table entry, you use the enternal function SETCTAB. The form of the statement would be:

```
SETCTAB (%SOURCECOLOR,
   %SCREENCOLOR,
   %RESULTCOLOR)
```

The following example would alter the color table so that when an orange dot was printed onto a blue background, the result would be green:

```
SETCTAB (%9, %6, %12)
```

Table 3 shows a summary of the graphics colors and their color values.

The black-and-white equivalent of the color table is the *transfer option*, which describes the logical operation used to place dots on the screen. De-

Variable	Description
EOF	holds reference number of file causing an EOF error
ERR	holds error type code of most recent error
FRE	holds amount of remaining bytes of memory available
HPOS	holds/controls cursor horizontal position
INDENT	holds/controls number of spaces to indent FOR . . . NEXT loops in listings
KBD	holds the ASCII value of the last key pressed
OUTREC	holds/controls the maximum line length output by the LIST command
PREFIX$	holds/sets current SOS pathname prefix
VPOS	holds/controls current cursor vertical position

Table 5f: *A summary of Business BASIC reserved system variables.*

Procedure	Description
DOTAT	plots a single dot at a given position
DOTREL	plots a dot relative to current position
DRAWIMAGE	draws a rectangular bit-map image at current position
FILLCOLOR	sets background color
FILLPORT	fills current VIEWPORT with FILLCOLOR
GLOAD	loads and displays a FOTO file from disk
GRAFIXMODE	specifies graphics mode and buffer choice
GRAFIXON	switches display to current graphics mode and buffer
GSAVE	saves current graphics display as a FOTO file on disk
INITGRAFIX	sets full-screen VIEWPORT, places cursor at upper left-hand corner and sets normal color and transfer tables
LINEREL	draws a line relative to current position
LINETO	draws a line from current to an absolute position
MOVEREL	positions cursor relative to current position
MOVETO	positions cursor at an absolute position
NEWFONT	used to specify a new graphics character font
PENCOLOR	sets current PLOT and DRAW color
RELEASE	frees highest graphics buffer memory
SETCTAB	sets a color-table entry
SYSFONT	causes normal system character set to be used as graphics character font
VIEWPORT	defines graphics-drawing window size and position
XFEROPTION	defines the logical operation that places dots on the screen
XLOC	returns graphics-cursor x position
XYCOLOR	returns color of dot on screen at current position
YLOC	returns graphics-cursor y position

Table 5g: *A summary of Business BASIC graphics procedures.*

pending upon the option specified, a dot (or its inverse) may replace existing data, overlay it, invert it, or erase it with new data. The XFEROPTION procedure and an argument specify the transfer mode. The transfer option may also be used with color data, but predicting the results is difficult.

Although circle drawing and turtle graphics are not supported, BGRAF is still a very nice package of routines that should allow you to produce a wide variety of color graphics. (See table 5g for a summary.)

Business BASIC Performance

Although Business BASIC is much more powerful than the Apple II's Applesoft BASIC, it is not much faster. Tests with the series of sixteen benchmark programs shown in listing 1 indicated that while Business BASIC is faster than Applesoft in some areas, it is slower in others. The net result should be a slight to medium speed improvement, depending upon the program being run.

The best test in the series was probably the Sieve of Eratosthenes prime-number program used by Jim Gilbreath (see "A High-Level Language Benchmark," September 1981 BYTE, page 180). Although this program is more representative of average program execution than any of the other benchmarks, it uses only addition and subtraction and does not have a wide variety of BASIC statements. In this test, the Apple III proved to be slightly faster than the Apple II but slower than the IBM Personal Computer or the 4-MHz Z80.

The execution speed advantage of the 6502B is largely cancelled out by the complexity of Business BASIC.

From the results of this limited set of benchmarks, it seems that the execution speed advantage of the Apple III's 6502B is largely cancelled out by the increased complexity of Business BASIC. However, I suspect that in larger programs Business BASIC will turn out to be a good deal faster than Applesoft. The combination of its powerful built-in features and invocable modules will eliminate the code required in Applesoft to accomplish the same functions. Also, if the benchmark programs had included the appropriate code to turn off the video screen during time-critical calculations, an additional 30 percent speed increase could have been gained by allowing the 6502B to run at 2 MHz. This would have placed the Apple III ahead of the IBM and Z80 computers in many tests.

Although benchmarks always have some validity, they may or may not be significant in a given application. It is best to approach the results with caution—the programmer frequently

Listing 1: *Execution benchmark programs. See table 6 for a summary of their results.*

Listing 1a: *tests a null loop.*

```
60    A=2.71828
80    B=3.14159
100     FOR I=1 TO 5000
320        NEXT I
```

Listing 1b: *tests REM execution time.*

```
100     FOR I=1 TO 5000
120        REM
140        REM
160        REM
180        REM
200        REM
210        REM
240        REM
260        REM
280        REM
300        REM
320        NEXT I
```

Listing 1c: *tests the IF. . .THEN statement.*

```
60    A=2.71828
80    B=3.14159
100     FOR I=1 TO 5000
120        IF A<B THEN 320
320        NEXT I
```

Listing 1d: *tests addition.*

```
60    A=2.71828
80    B=3.14159
100     FOR I=1 TO 5000
120        C=A+B
320        NEXT I
```

Listing 1e: *tests multiplication.*

```
60    A=2.71828
80    B=3.14159
100     FOR I=1 TO 5000
120        C=A*B
320        NEXT I
```

Listing 1f: *tests division.*

```
60    A=2.71828
80    B=3.14159
100     FOR I=1 TO 5000
120        C=A/B
320        NEXT I
```

Listing 1g: *tests exponentiation.*

```
60    A=2.71828
80    B=3.14159
100     FOR I=1 TO 5000
120        C=A^B
320        NEXT I
```

Listing 1 continued on page 124



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Listing 1 continued:

Listing 1h: *tests transcendental functions.*

```
60    A=2.71828
80    B=3.14159
100    FOR I=1 TO 5000
120       C=SIN(A)
320       NEXT I
```

Listing 1i: *tests the LOG function.*

```
60    A=2.71828
80    B=3.14159
100    FOR I=1 TO 5000
120       C=LOG(B)
320       NEXT I
```

Listing 1j: *tests the ON. . .GOTO statement.*

```
80    M=2
100    FOR I=1 TO 5000
120       ON M GOTO 80,320,100
320       NEXT I
```

Listing 1k: *tests the GOSUB/RETURN statement.*

```
60    A=2.71828
80    B=3.14159
100    FOR I=1 TO 5000
120       GOSUB 1000
320       NEXT I
1000    RETURN
```

Listing 1l: *tests the INT (integer) function.*

```
60    A=2.71828
80    B=3.14159
100    FOR I=1 TO 5000
120       C=INT(A)
320       NEXT I
```

Listing 1m: *tests the MID$ function.*

```
80    A$="abcdefghijklm"
100    FOR I=1 TO 5000
120       B$=MID$(A$,6,6)
320       NEXT I
410    PRINT""
420    END
```

Listing 1n: *tests random number speed.*

```
60    A=2.71828
80    B=3.14159
100    FOR I=1 TO 5000
120       C=RND(1)
320       NEXT I
```

Listing 1o: *tests the CHR$ function.*

```
80    A$="abcdefghijklm"
100    FOR I=1 TO 5000
120       C$=CHR$(50)
320       NEXT I
```

Listing 1 continued on page 126

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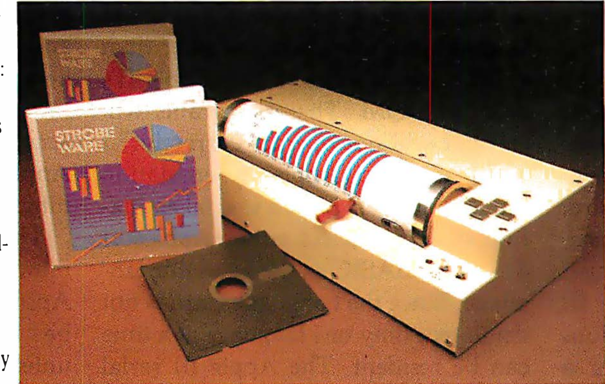
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Listing 1 continued:

Listing 1p: *Jim Gilbreath's Sieve of Eratosthenes prime-number program.*

```
1    SIZE=7000
2    DIM FLAGS(7001)
3    PRINT"only 1 iteration"
5    COUNT=0
6    FOR I=1 TO SIZE
7      FLAGS(I)=1
8      NEXT I
9     FOR I=0 TO SIZE
10       IF FLAGS(I)=0 THEN 18
11       PRIME=I+I+3
12       K=I+PRIME
13       IF K>SIZE THEN 17
14       FLAGS(K)=0
15       K=K+PRIME
16       GOTO 13
17       COUNT=COUNT+1
18       NEXT I
19    PRINT COUNT,"primes";""
```

Listing 2: *Disk-access benchmark programs. Listings 2a and 2b are write and read tests for the Apple III. Similar programs were used for the Apple II and the IBM Personal Computer.*

(2a)

```
40    A$="12345678123456781234567812345678"
60    B$=A$+A$+A$+A$
80    NR=500
100    OPEN#1,"TEST"
140    FOR I=1 TO NR
160       INPUT#1;B$
200       NEXT I
220    CLOSE#1
240    PRINT"DONE"
```

(2b)

```
40    A$="12345678123456781234567812345678"
60    B$=A$+A$+A$+A$
80    NR=500
100    OPEN#1,"TEST"
140    FOR I=1 TO NR
160       PRINT#1;B$
200       NEXT I
220    CLOSE#1
240    PRINT"DONE"
```

Listing #	Benchmark	Apple III Business BASIC	Apple II Applesoft BASIC	IBM Advanced BASIC	4-MHz Z80 MBASIC 4.51
1a	empty loop	8.9	6.7	6.43	5.81
1b	10 REMs	19.2	19.5	21.0	15.8
1c	IF. . .THEN	22.9	19.8	17.6	14.9
1d	addition	19.5	17.5	18.2	16.3
1e	multiplication	25.0	27.3	19.6	19.9
1f	division	27.6	28.8	23.8	24.9
1g	exponentiation	184.5	249.1	84.8	121.1
1h	sine(x)	98.0	193.1	73.9	63.1
1i	log(x)	87.1	113.6	49.4	55.4
1j	ON. . .GOTO	18.6	17.5	17.3	12.9
1k	GOSUB/RETURN	16.4	13.6	12.4	9.4
1l	INT(x)	20.0	19.3	18.1	15.5
1m	MID$	37.3	32.5	23.0	18.6
1n	RND(x)	90.5	33.1	18.4	19.7
1o	CHR$	26.8	23.5	16.2	13.4
1p	prime numbers	222.4	224.4	190.0	151.0

Table 6: *Table of execution times (in seconds) for a series of benchmark tests run on Apple III Business BASIC, Apple II Applesoft BASIC, IBM Personal Computer Advanced BASIC, and a 4-MHz Z80 computer running Microsoft's MBASIC 4.51. The results shown may or may not be indicative of performance in a particular application; they should be interpreted with caution. The results for the IBM Personal Computer and the Z80 microcomputer were taken from Gregg Williams' "A Closer Look at the IBM Personal Computer" (January 1982 BYTE, page 54). See listing 1 for the benchmark programs used.*

makes more difference than the machine. (The benchmark results are summarized in table 6.)

Apple II Emulation

The Apple III's ability to emulate an Apple II is an extremely useful feature that allows access to the tremendous volume of Apple II software. Virtually all Apple II DOS 3.3 programs in either Applesoft or Integer BASIC can be run on the Apple III without change—the few exceptions are those programs that require a RAM card or language system to operate. Also, some of the Apple II arcade games use their own routines to read the game paddles rather than calling the routines in the Apple II's monitor ROM. These programs will run but will not operate correctly.

To use the Apple II emulation mode, you must boot a special emulation disk and select either Applesoft or Integer BASIC as the available language. Since the Language Card is not emulated, only one language at a time can be resident. The Apple III serial port can be configured to emulate either an Apple II serial card or a communications card. The data rates and carriage-return handling can also be specified. Once the emulation parameters are specified or the defaults accepted, you can boot a normal Apple II DOS 3.3 disk and start running.

The emulation mode has a few minor weak points. If you have an Apple III Silentype printer, it will not be accessible in emulation mode unless you install an Apple II Silen-

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Apple SOS 1.1

Organization
Four data surfaces, 153 tracks per surface, 16 sectors per track, 512 bytes per sector, 2448 sectors per surface, 9792 sectors per drive

Specifications
Data transfer rate: 5 megabits per second; average seek time: 95 milliseconds; rotational speed: 3600 revolutions per minute; ready to operate: 60 seconds

Interface
Interface card occupies one Apple III expansion slot; one drive per interface card, up to four drives per system

Special features
Power-up self-test and disk scan; automatic bad-sector relocation; error checking and limited error correction

type interface card, which may violate FCC radio-frequency radiation limits. Nor can you access the Profile hard-disk drive—Apple II and Apple III files won't mix on the same disk. Also, the RGB (red-green-blue) video outputs will not provide color signals while emulating Apple II graphics, but the composite video outputs will work normally.

The Profile

The Profile hard-disk drive is the newest component of the Apple III family and a worthy occupant of an expansion slot. With a 5-megabyte capacity, integral Z8-based controller, and built-in power supply, the Profile is a self-contained intelligent subsystem with its own self-test, error checking, and bad-sector relocation facilities.

When powered up, the Profile's controller waits for the disk to come up to speed and does a data integrity check by stepping from track to track to verify that all disk sectors read correctly. If a bad sector is found, either during this process or during normal activity, the Profile attempts to correct the data errors and then relocates as much data as possible to an alternate good sector.

The key component in the Profile is the ST-506, a 5¼-inch hard-disk drive manufactured by Seagate Technology Inc. The ST-506 uses the sealed disk environment and low-altitude (10-microinch) flying heads that characterize all Winchester-technology disk drives (see photo 11). Because a number of vendors produce drives that are plug-compatible with the ST-506, Apple should have no trouble producing Profiles even if Seagate's supplies get short.

During operation the disk drive is relatively quiet, emitting a soft tone as it steps from track to track. Between accesses you can hear the main drive motor, but the sound should not be obtrusive or even audible in most office environments.

The Profile is styled to match the rest of the Apple III system and may be positioned on top of or adjacent to the computer.

I found the Profile a pleasure to use. Its capacity is equivalent to that of about 35 normal Apple floppy disks, and its data throughput is about 10 times faster. Viewing its capacity in other terms, the Profile can hold over 1200 pages of typed text or more than 300 high-resolution graphics pictures occupying 16K bytes apiece.

The Profile's performance is excellent. In the disk-access benchmark programs shown in listing 2, the Profile effectively tripled the program speed when compared to an Apple or IBM floppy disk. Considering that a significant proportion of the program execution time is used to execute the BASIC program statements, the actual increase in disk-access speed would seem to be even higher. (The results of the disk-access benchmarks are summarized in table 7.)

The weakest point of the Profile and other similar products is data backup. If a hard disk fails, you can lose a great deal of important data. The only solution is to periodically back up the most critical files onto floppy disks or onto a second Profile hard-disk unit. (Apple Computer will happily allow you to connect up to four Profiles to your Apple III, at a total cost of $13,996 in addition to the cost of the Apple III.) However, chances are very slim that the entire Profile would be wiped out if a critical component failed. After repair, it should be possible to recover virtually all the original data in most cases.



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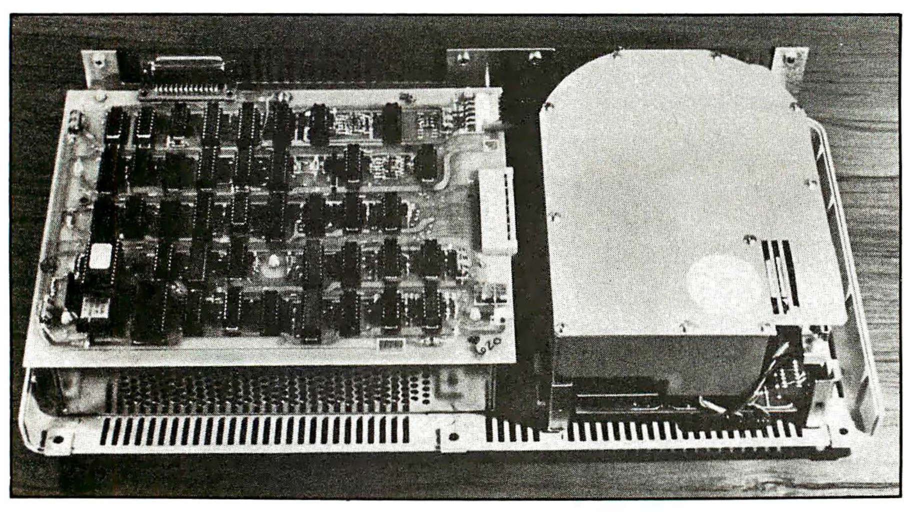


Photo 11: *The Profile with its top cover removed. The intelligent controller is shown on the left with the switching power supply beneath it. The HDA (hard-disk assembly) with its sealed internal environment is mounted on the right.*

	Apple III Profile	Apple III Floppy Disk	Apple II Floppy Disk	IBM Floppy Disk
Write	13.2	37.3	234	32
Read	10.2	33.2	273	22.9

Table 7: *A summary of disk-access-time benchmarks comparing the performance of the Apple III Profile hard-disk drive and the Apple III, the Apple II, and the IBM Personal Computer floppy-disk drives. The table shows the times (in seconds) taken to read and write 500 disk records.*

At $3499, the Profile isn't inexpensive—none of the available hard-disk subsystems are—but it provides a truly significant extension to the capabilities of the Apple III system.

Documentation

Apple Computer's documentation has always been excellent, and the manuals provided with the Apple III are no exception. All the manuals are in the familiar 6- by 8½-inch (12.8- by 21.6-cm) format, and a new flap has been added to the back cover so that the manual title is visible while the book is on the shelf. The manuals are all clearly written with numerous charts, tables, and screen photos to illustrate points described in the text.

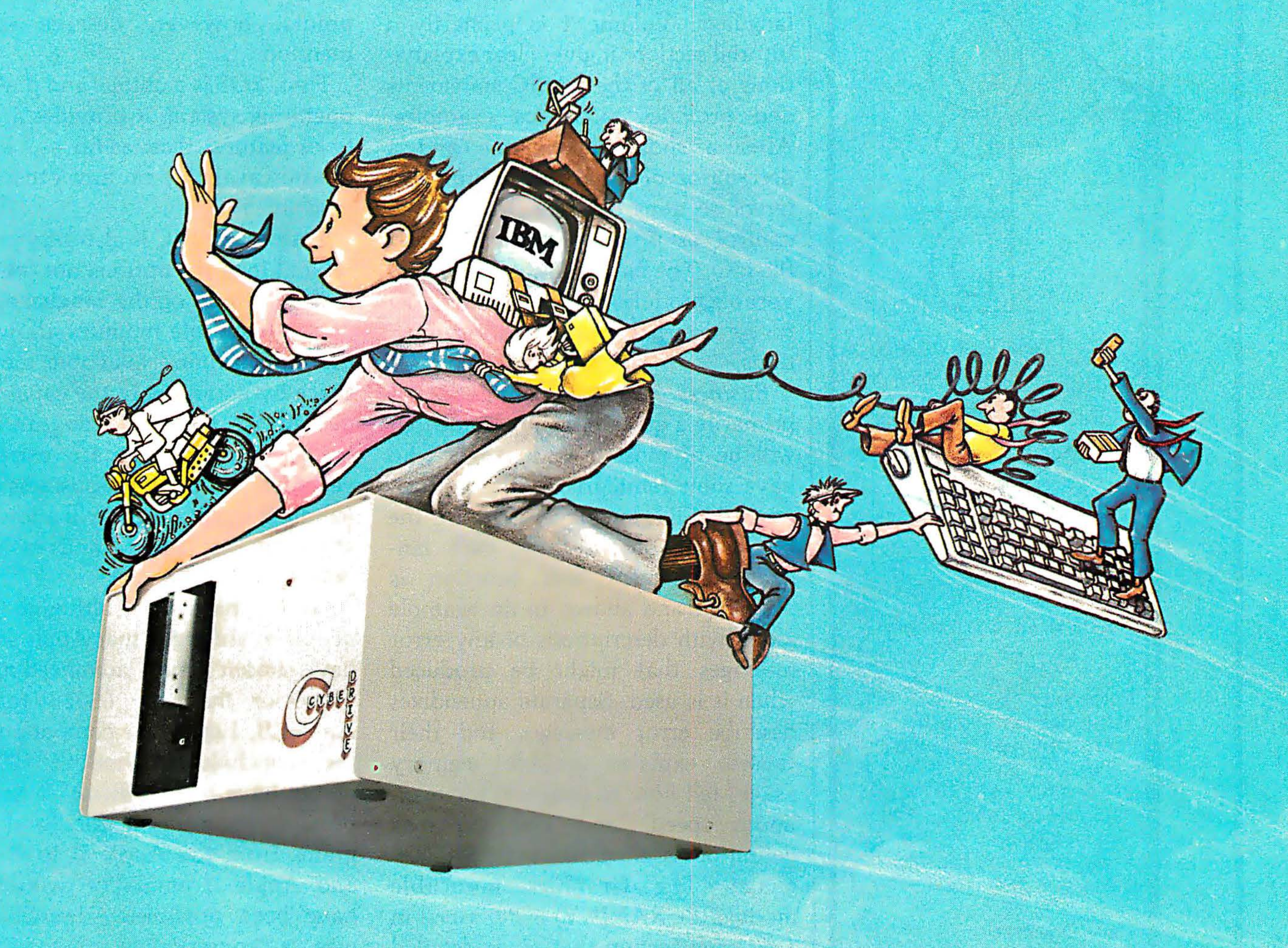
With a Business BASIC system, you receive four manuals: the *Owner's Guide* and *Standard Device Drivers* deal with Apple III features and SOS, while volumes one and two of *Apple Business BASIC* provide a comprehensive description of the language.

The *Owner's Guide* explains how to set up the Apple III system and describes various aspects of SOS and the Apple III hardware. There are sections about system installation and start-up, the operating system, the System Configuration Program, and the machine itself. Appendixes explain error messages, describe proper disk care and handling, give I/O port specifications, and tell you how to use the Apple II Emulator. The information is presented in a clear, easy-to-read style and should be sufficient to get any novice started.

Standard Device Drivers provides complete specifications and descriptions of the operation of all of the standard I/O device-driver routines. After a short section that explains what device drivers are, the manual describes the System Configuration Program. Separate sections describe each individual driver in detail. The appendixes contain quick references for all the drivers, an explanation of the system error messages, and a description of the console data formats.

With a BASIC system, you'll get *Business BASIC* volumes 1 and 2. Although the manuals were not de-

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signed to teach BASIC, the 335 pages contain all the information required to learn Apple's version of that language. Volume 1 is primarily a tutorial section; it gives clear explanations of all of the BASIC statements and provides numerous examples. After a short introduction and a description of the BASIC editor, different sections describe BASIC I/O, control of program execution, and file I/O. The manual also explains invocable modules and shows you how to use external procedures and functions.

Business BASIC volume 2 is primarily a quick reference quide that will be of most use to people who have some familiarity with the Business BASIC language. Within the BASIC reference section, each language statement and function is described and shown in an example along with descriptions of any error messages that might be produced when it is used. Separate appendixes describe error messages and their causes, explain variable memory usage, tell how to program for maximum speed, and give syntactic definitions of the Business BASIC language. The Graphics invocable module (BGRAF.INV) is described in a 57-page section that gives detailed examples of plotting and drawing, saving pictures on disk, creating graphics text fonts, and setting up your own color and transfer tables.

If you purchase Apple III Pascal, you'll get an additional four manuals that describe the Pascal system, utility programs, and the Pascal language. One distinct benefit of Apple III Pascal is that the description of the Pascal assembler provides details about the 6502 enhanced features that are not found in any of the other manuals. Unfortunately, even though the BASIC invocable modules are written in Pascal, the manuals do not tell you how to write them. This may not be important to small-business users; nevertheless, the information should be available.

Summary

It is impossible to do the Apple III justice in one article. The machine is very flexible and has a mix of features and capabilities that are unmatched in any of its competitors. Some points, however, deserve special mention.

First, SOS is a unique and powerful operating system; it provides a variety of features that, as far as I know, are not available on any other 8-bit machine.

Business BASIC is also very powerful and includes options not found in most versions of the language. The use of invocable modules allows the user to maximize available memory space by adding only the capabilities needed. Its I/O-formatting and file-handling capabilities are extremely versatile and, for most business data-handling applications, will allow programs to be shorter and easier to debug.

As for hardware, although some people might argue that Apple should have chosen a more advanced microprocessor than the 6502B for the Apple III, I think the company made the right choice. Without the 6502B it would have been difficult, if not impossible, to transfer files and programs from the Apple II to the III, and Apple II emulation would not have been possible. Admittedly, it was a conservative choice—more powerful processors are available—but actual processor performance is much less important than software availability. Apple's choice clearly maximizes the usability of the system.

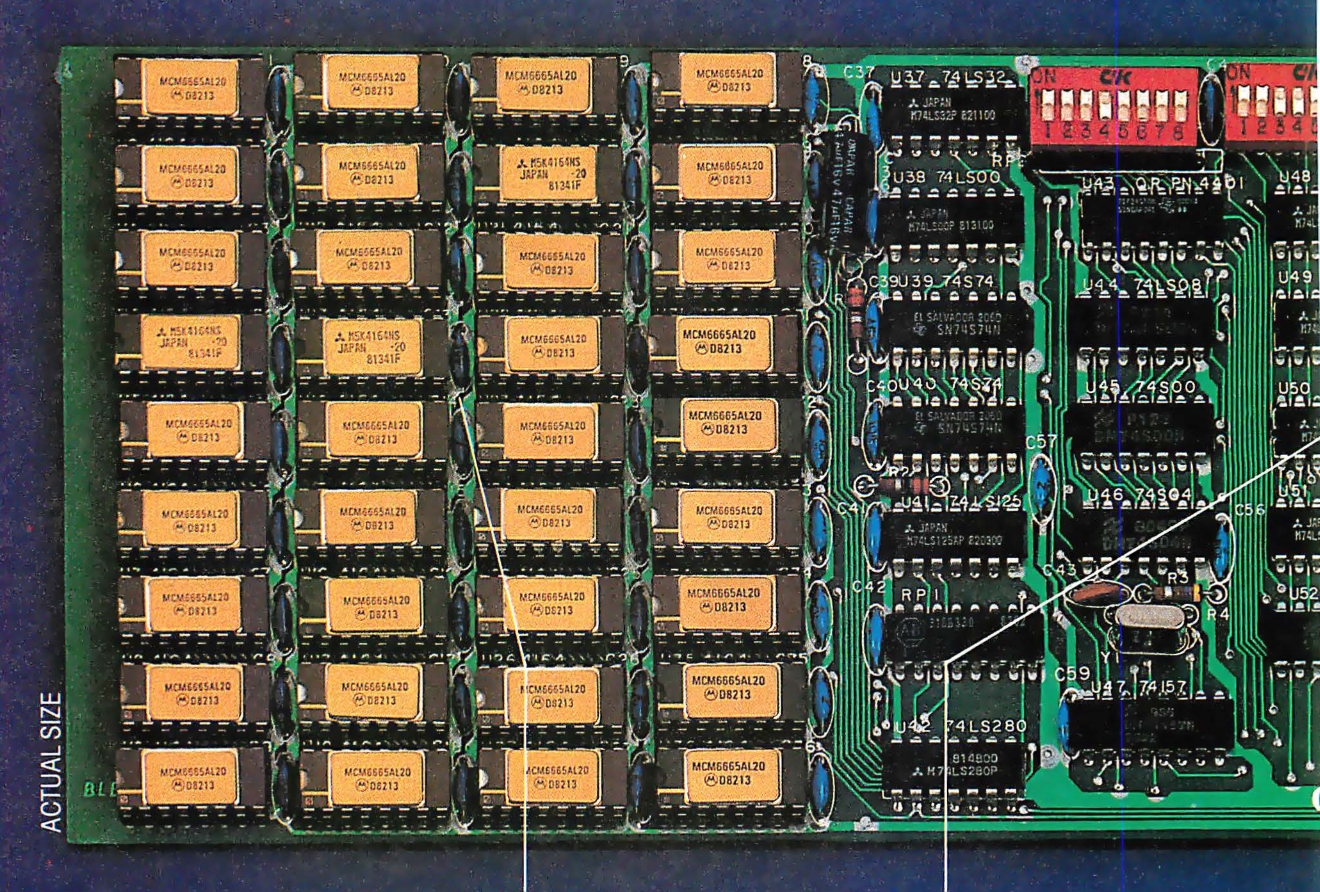
The Profile hard-disk drive is a significant enhancement to the Apple III. Its speed and high capacity will eliminate 99 percent of the disk swapping required when using only floppy disks, and the SOS nested directory structures will keep it well organized.

Finally, one of the strongest points in favor of the Apple III is Apple Computer Inc. When early Apple III users had problems with the first machines, Apple simply replaced the entire computer immediately—as many as two or three times in some cases. This unqualified backing of its products shows a commitment to customer satisfaction unequaled in the industry. ■

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Computers Can Play a Dual Role for Disabled Individuals

Besides providing special assistance, microcomputers should give disabled individuals access to standard software.

Gregg Vanderheiden, Director
Trace Research and Development Center
314 Waisman Center
1500 Highland Ave.
Madison, WI 53706

The move toward more portable and flexible microcomputers is revolutionizing the design and development of electronic assistive devices for the disabled, ensuring the status of powerful, low-cost microcomputers as valuable tools for disabled individuals and those working with them.

The past few years have witnessed a tremendous increase in the number of individuals and small groups involved in the development of special aids for disabled persons. Microcomputers have given individual designers who don't have access to extensive laboratory and production facilities the capability of developing sophisticated electronic aids. This is not to say that the design of aids to assist disabled individuals is easy or can be easily developed in a few weekends or evenings. The worthwhile developments in this area have taken a lot of time and effort, not only in programming and interfacing, but also in carefully studying the real needs of the disabled individuals and the many barriers and practical considerations that are involved in the successful applications of technology to meet their needs.

Worthwhile developments require careful study of disabled individuals' real needs.

The influx of new people into this area has resulted in a wealth of new ideas, energy, and enthusiasm. The purpose of this article is to provide an overview of some of the many areas in which microcomputers can serve the needs of disabled individuals and to discuss a few major concepts important to the development of successful applicable software. I hope this overview will stimulate new ideas, approaches, and applications for microcomputers in those interested in getting involved in designing for the disabled. The basic concepts presented can help you learn from and build upon, rather than duplicate, the early work and mistakes in this area.

A Dual Role for Microcomputers

When we first think about the use of microcomputers by disabled individuals, our minds usually turn to thoughts of text-to-braille translating programs, special communication aids, programs that can teach sign language, etc. These all involve the development of special software that can be run on the computer to provide a specific function required by a disabled individual.

In considering the use of computers by disabled individuals, however, it is very important to remember that disabled people also need to use the same programs and accomplish the same tasks as anyone else. Thus the

Gregg Vanderheiden is director of the Trace Research and Development Center for the Severely Communicatively Handicapped at the University of Wisconsin-Madison.

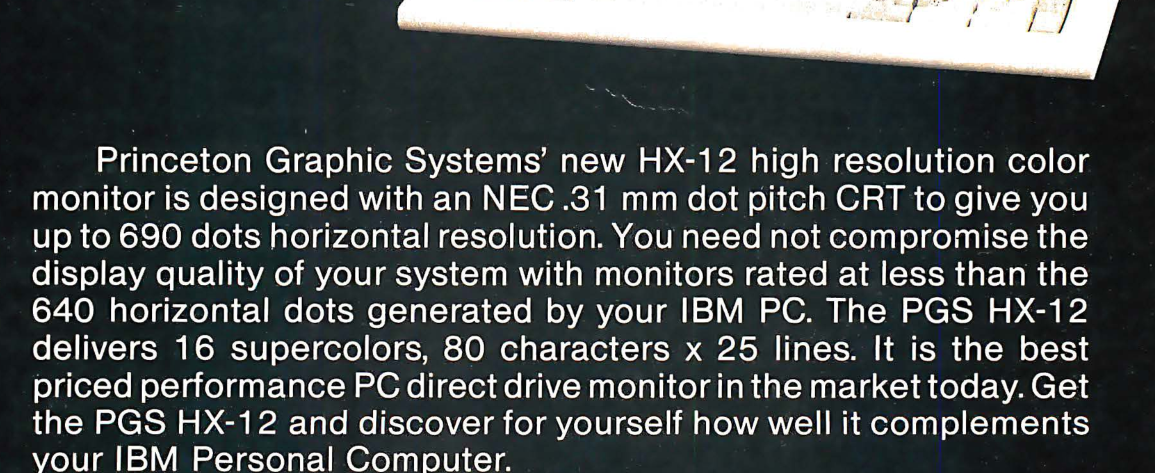
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blind individual who may be able to make good use of a text-to-braille program also needs to be able to use standard text editors, spreadsheet programs (e.g., Visicalc), and database managers, to name only a few. Similarly, the physically disabled individuals who could use a game or writing program that requires only the operation of a single switch also need to be able to use the standard educational software as well as the accounting programs and computers at the companies considering them for jobs. This is the dual role that microcomputers must fill: they must help disabled persons perform tasks denied to them because of their disability, and they must be physically modified to allow disabled persons to tap all the microcomputers' computing and word-processing powers.

At present, the vast majority of the software being developed for disabled individuals is limited to providing for a special need, rather than allowing the use of common general-purpose software. These special programs (although often quite sophisticated) are generally easy to implement because the full capabilities of the computer are available to the programmer. They do not, however, address the greater need for disabled individuals to be able to use standard systems.

Trying to provide access to standard software programs for individuals who cannot see the video display or cannot use the keyboard is very difficult. In many cases, the more powerful standard software takes complete control of the computer when it is loaded, disabling the special routines or programs intended to provide access to disabled individuals. This is true even when the special routines are hidden in remote areas of the memory. In addition, the standard programs themselves are often "locked," and the source code is unavailable, making any direct modification of the programs impossible.

Despite the many barriers, strategies are being developed now that can allow extremely motor-impaired individuals to access all standard software, even though the user may have as little controlled movement as an eyeblink.

Providing Special Functions

It would be impossible to quote an exhaustive list of the special functions microcomputers could provide for disabled individuals. Almost any aspect of human activity that has been impaired could potentially be aided to some degree through the use of microcomputers as processors, manipulators, or controllers.

Sensory enhancement/translation: Microcomputers can be used to provide either a clarification of audio or visual information so that it can be more easily understood or a translation from one medium to another. For example, microcomputers can be used to expand visual displays, provide visual displays of auditory information, provide auditory output of visual information, translate a limited, spoken vocabulary into text, and provide tactile displays and feedback to individuals both deaf and blind.

Manipulator/controller: For individuals with severe motor impairments, the use of remote actuators and powered artificial remote pros-

theses (or robotics) to give them manipulative capabilities has been proposed. One of the difficulties has been the large number of signals that are required in order to control such robots or manipulators. One role for microcomputers might be to help control these remote manipulators by developing and remembering complex movement command strings for specific types of activities. These command strings could then be called upon by the user, using a small number of commands, thus allowing complex motions to be made with reasonable speed and ease.

Information amplification (for motor impaired): The problem of slow information transfer is not restricted to the manipulator/control field. In fact, its greatest impact is probably in the area of communication and writing. Here the speed with which one can transfer information is crucial, and the demand for reasonable speed is extremely high. A difference in speed by a factor of 4 or 5 (the average factor for a motor-impaired individual is around 10 to 20) can make the difference between being able to complete a day's work in a day and taking a week to accomplish a day's work. Similarly, it can be the difference between being able to complete one's homework each night and being able to do one night's homework every week or two. The microcomputer can be used in a number of ways, however, to increase or amplify the amount of information that can be relayed with a given number of keystrokes or signals. Most of these techniques take advantage of redundancy in information transferred, but others are more involved.

A simple example would be an abbreviation expansion routine that would allow an individual to abbreviate all commonly used words and greatly reduce the number of keystrokes required to type out messages, programs, etc. The program would automatically expand the abbreviations as the user typed them. The abbreviations could represent commonly used words, mnemonics, phrases, sentences, or entire blocks of frequently used information.

Another technique would be to use a large word-base that could anticipate the word being typed, thus truncating the process of spelling words out. This can be done based upon word and letter frequency. More elaborate schemes involve looking at idea-to-text or concept-to-text (or even concept-to-speech) translation.

Also being explored is a semantic-feature-based phrase/sentence recall system in which three to five keystrokes would define an entire sentence (see "Minspeak" by Bruce Baker, page 186). Only about 60 keys are involved, but their meanings vary as a consequence of the order in which they are pressed. Although this approach at first seems complex, a system like this may be necessary in order to provide the information amplification necessary to offset the severe information-transfer problem that many motion-impaired individuals have. Advances in this field need not be limited to assisting disabled individuals either.

Special control interfaces to other devices: A general method for increasing the information-transfer rate

uses microcomputers to provide a special interface between the disabled individuals and the device(s) that they are trying to control. The purpose of this special interface would be to obtain the best possible match between individuals' residual capabilities and the characteristics of the systems that they are using.

Depending upon the severity of the physical handicap, these special interfacing techniques can take a variety of forms. For severely disabled individuals, single-switch input systems can be used; the microcomputer continually presents choices to the user until the user responds by activating a switch.

More common and effective, however, are various special direct-selection or encoding input techniques. For individuals who have head control, screen-based optical headpointing schemes (similar to a long-range light pen) can be used. Other individuals may use expanded and/or recessed keyboards. For those who are able to point but unable to point to a large enough array of elements to represent a full keyboard, smaller arrays consisting of numbers can be used in an encoding fashion to specify the letters, words, etc. Efforts are also currently being directed toward cost-effective methods of using the eyes, both for encoding and for direct selection of items from a display. All of these approaches can be adapted in size and arrangement in order to meet best the needs and capabilities of specific individuals.

A special interface obtains the best match between individuals' residual capabilities and the characteristics of the system they are using.

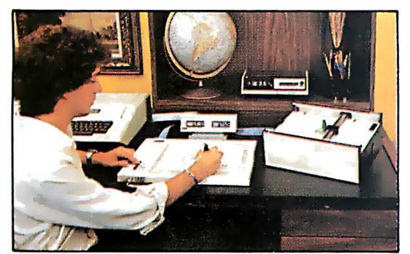
Recreation and development aids: Disabled individuals can, of course, use microcomputers to play games in the same manner as anyone else. For individuals with severe physical or sensory disabilities, however, microcomputers can play a more extensive role than just recreation. For example, manipulation of objects and exploration of environment important to development in children may not be possible. A specially interfaced microcomputer may be able to offset some of this disability by providing children with a reliable means to control, explore, and manipulate objects either in real space or on a video display. It may also allow individuals to be able to move themselves about in space to gain new perspectives on their environments as well as to reach and act on the objects in it.

Educational aids: In the educational field, a number of specific problem areas can be addressed in part by microcomputers. One area of difficulty involves the slow rate of response of severely physically disabled individuals. This response rate makes any remedial drill or practice session extremely time-consuming

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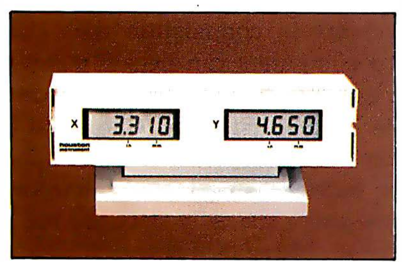
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(and therefore expensive in terms of personnel time, etc.). Microcomputers can be used to allow individuals to practice lessons independently and at their own speed.

Learning that involves manipulation, such as might be found in chemistry, physics, and other sciences, presents another problem area. Here, microcomputers and computer-aided instruction can allow an individual to manipulate and explore ideas, concepts, figures, etc., in structured but flexible ways. Such programs can allow severely physically disabled individuals to handle "flasks" and "chemicals" on the TV screen and carry out experiments and manipulations that would otherwise be beyond their direct control.

Another whole area for microcomputers in education would be their use not as direct teaching aids but as aids in providing fundamental facilities necessary for a meaningful and effective education. Examples of these aids for a "normal" individual might be eyeglasses or a pencil and paper. The need to see, read and write, take notes, and do independent work are of course necessary capabilities for receiving an education within our current system. The severely physically disabled individual who has no ability to use a pencil and paper, to take notes, to write, or to do independent work is at an extreme disadvantage. Microcomputer-based writing systems designed to provide the same flexibility as a scratch pad and pencil could be used to provide these individuals with the capabilities for appropriate and adequate participation in their educational programs.

Finally, microcomputers can be used to teach fundamental programming skills. Because of the many ways in which microcomputers can aid individuals with disabilities, and because of the direction in which many aspects of the employment world are heading, it is quite clear that microcomputers hold future vocational potential for disabled individuals, whether their vocational direction is in the computer field or not. Computer literacy and the ability to reconfigure or oversee the reconfiguring of computer systems to meet their changing needs may be extremely important capabilities for disabled individuals to have.

Communication aids: Because of the nonportability of microcomputers up to now, their use has been limited mostly to work-station types of applications. These applications include computer-aided writing and filing systems as well as work-station phone control and phone communications using the new speech-output capabilities. However, the stationary systems have not been able to meaningfully address the conversational needs of individuals with severe speech impairments.

The recent introduction, though, of portable and hand-held computers is opening up the potential for microcomputers to move out of the stationary writing-aid category and begin to address the categories of portable writing/note-taking aids and conversational communication aids. Because of the fine motor control required, these portable units will find their greatest initial application for individuals having mild to moderate physical disabilities. When used as components within systems having other input techniques, however, they may also be used by individuals having more severe disabilities. The limited memory, I/O (input/output), and control capabilities of these systems are currently hampering their application in many areas. In time, the memory capabilities may greatly expand, but the I/O and control capabilities are generally not emphasized in a portable unit and may continue to present problems for awhile.

The major barrier for using microcomputers as communication aids, however, is the need for custom interfacing to achieve optimum speed. This usually involves the development of special interfaces not commercially available. As I will discuss in more detail later, the use of custom hardware in conjunction with standard computers can negate many of the advantages of using a microcomputer in the first place. Care must be taken, therefore, when making a decision between an adapted microcomputer and a specially designed aid to solve problems in this area.

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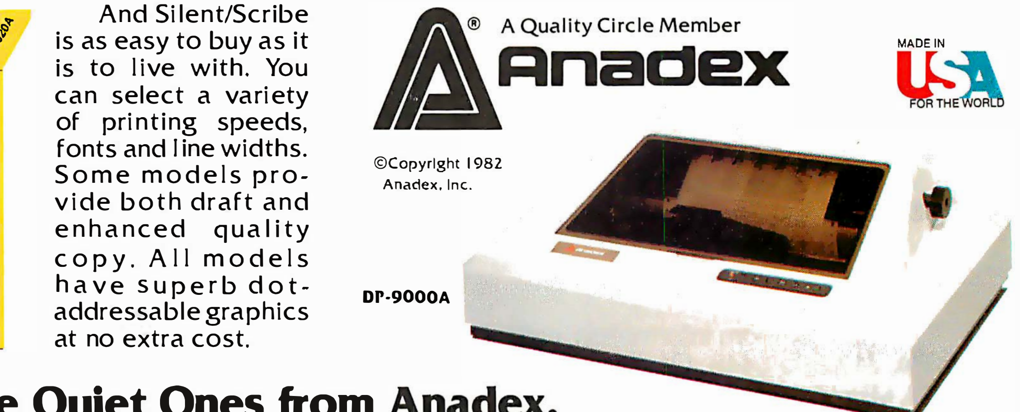
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	13.3	200	200	—	—	—
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	16.4	—	—	200	200	164
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Information resource/management: Disabled individuals could use a microcomputer for information resource/management in all of the same ways that able-bodied individuals can. In addition to these uses, computers can help physically or sensorily disabled individuals to access materials that would normally be difficult for them to handle in a number of ways. Sensory or, particularly, physical disabilities may prevent these persons from making effective use of notebooks, filing systems, calendars, dictionaries, phone lists, etc., due to their inability to quickly manipulate and scan these materials. Microcomputer-based systems with interfaces designed specifically to work with the individual's residual capabilities can provide effective and efficient means of paralleling all of these functions. At present, most of these applications are in the area of *user-generated* information storage and retrieval, although in some cases, such as a dictionary, materials or databases are being developed for general use and dissemination.

Security/monitoring systems: A major barrier to the ability of many disabled or aging persons to live independently is the lack of effective and economical means to ensure their safety and the ability to summon help. Some ways in which a microcomputer could aid in these independent living endeavors would be through the provision of mechanisms for physically disabled individuals to control the locks and windows in their homes, emergency-call systems for individuals who have difficulty in making a call or who are unable to speak, monitoring systems for persons who could fall or in some way render themselves unconscious and unable to call for help, and medication-reminder systems.

A monitoring system could run periodic checks and call for help if the individual does not respond to the system's queries. Reminder systems can be developed both to provide reminders as to when medication should be taken and to check whether certain actions necessary in the taking of the medication (e.g., opening the refrigerator) have been done. Lack of

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response to these reminders could be used as an alerting signal to the monitoring/call system, which could, in turn, summon aid.

Cognitive and language-processing assistance: Congenital or acquired conditions often leave an individual with impaired cognitive processing. In some cases, it is a general processing deficit, as in mental retardation. In other cases, it is a specific dysfunction of a particular process, such as short-term memory or the ability to program speech or remember names. The greatest obstacle to identifying effective applications of microcomputers in these areas is the limited knowledge about the processes and remediation methods in general. The prospect of microcomputer-based cognitive prostheses is still beyond the current state of the art but not beyond the imagination. The use of microcomputers in remediation, however, may be much closer and more realistic, especially in areas where extensive drill and practice are associated with the remediation process.

Providing Standard Functions

As I stated previously, it is important for disabled individuals to be able to use microcomputers for the same purposes as everyone else does. These purposes include word processing, computer games, computer-aided instruction, control (including environmental control in both the home and job site), financial planning, management, and general computing. In some cases, the disabled individual may use these standard capabilities (e.g., word processing) to help offset specific disabilities (e.g., inability to use a pencil). More and more, however, individuals need to access the standard computer programs because computers are an integral part of their education or jobs. As our society in general incorporates the use of computers into every facet of daily living, access to them is becoming more and more essential.

In order to provide disabled individuals with the ability to run standard software programs, transparent modifications that can circumvent the individual's particular disabilities need to be developed. (The word *transparent* is used here to refer to a technique that is invisible to any standard software programs—that is, modifications cannot be detected by any piece of standard software when this technique is used.) A completely transparent modification does not interfere with the standard program in any way. Similarly, the standard program cannot interfere or negate the modification. A few examples of transparent modifications may be useful here.

The simplest example of a transparent modification is a weight on a hinge that can be tipped to hold down the shift key. This mechanical modification can allow a one-handed or one-fingered (or headstick) typist to enter shift or control characters on the keyboard. There is no way for computers to tell in what manner the individuals are entering data, and any programs will run without modification.

A somewhat more flexible modification may be the use of a keyboard-emulator module, which would be inserted into the computer between the keyboard and the main computer board. Electrically, this keyboard emulator would look exactly like the standard keyboard. As a result, it would be impossible for the processor (or any software) to tell that the signals coming to it were not coming from the computer's keyboard.

The keyboard emulator would have a connector on the side that would accept RS-232C serial, parallel, or any desired signal format and inject the characters received into the computer as if they were typed on the keyboard. In this manner, persons using any one of a large number of special communication or control aids could directly control the computer as if they were typing on the keyboard.

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trol and communication rate. One individual might be using a "brow switch" and a special scanning display. Another individual could be using a light-beam headpointer. Still another might use Morse code or some other encoding system that requires the individuals simply to look at the characters they want on a display.

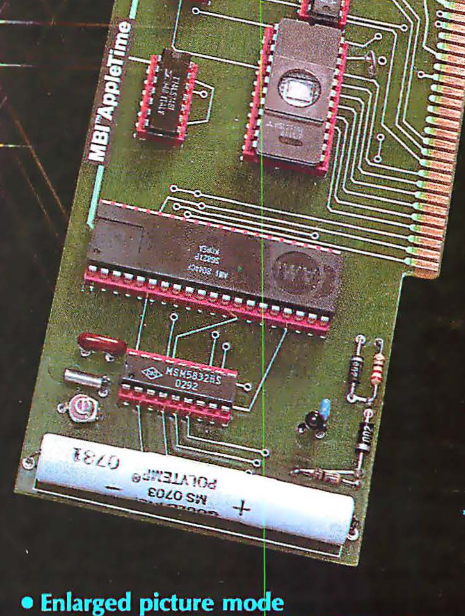
The outputs from these displays would then be fed into the keyboard emulator and then into the computer as "input from the keyboard." Such an arrangement would be completely transparent and allow these individuals to utilize *any* software controlled from the keyboard. (Game-paddle emulators can also be used to access other programs.)

In order to allow use of the computer in its normal fashion, most keyboard emulators also accept input from the keyboard and pass it along to the computer as well. Thus, with the keyboard emulator in place, the computer can be used in the standard way by disabled individuals.

Equipping one or more computers in a classroom with such keyboard emulators would allow disabled individuals with special communication aids to access and utilize the same educational programs and courseware as the other members of their class or school. Similarly, if a company had a terminal with an emulator installed, the terminal would be usable by disabled as well as able-bodied personnel without any modification to the company's systems or software. Because the module plugs in between the keyboard and the processor, it can also be removed at any time (and the keyboard plugged back into its normal slot) for testing or maintenance of the computer or terminal. Smart keyboard emulators can also be plugged into themselves to run self-diagnostics.

Another transparent modification deals with output rather than input: a special *audio screen* is connected to the computer's bus; instead of creating a video image, however, it has a special flat tablet that lies on the table beside the keyboard. As blind individuals move the cursor around on the tablet, they can cause the tablet to





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read out the words or letters their hands are "over." In this fashion, blind people can easily scan the screen and have it read off the contents in any random order they desire. Because they can move their hands around on the tablet, they can also get a "special feel" for the information. Because it is impossible for the main computer (or its software) to tell that this system is in place or in use, any software that uses the video display and pronounceable characters can be used by the blind individual. Thus, an individual would be able to access and use most standard software without modification.

It's obvious, of course, that programs that use a video display are designed for individuals who can see. The screen presents information to the user in a parallel format—that is, the information on the entire page is presented to the user at one time. Blind individuals using the above modification would be able to "see" the screen only a word or a character at a time. This would be equivalent to sighted persons trying to read and make sense out of words on a screen by looking at the screen through a soda straw (a character at a time) or a small tube (a word at a time). Although they could figure out what the screen said, the effectiveness of the visual display is decidedly decreased, and the organization and presentation of much of the information on the screen may be far from optimum for this type of "serial" input.

For this reason, programs written specifically for use by blind individuals use considerably different strategies for organizing and presenting information. Thus, although the audio-screen technique just described does provide access to standard software for blind individuals, it does not give them *equivalent* access to that of sighted individuals; nor does it give them *optimum* access. Unfortunately, the software that has been optimized for use by blind individuals is an extremely small fraction of the software generally available. It is likely we will see the amount of this software increase with little improvement in quality. As a result, such non-optimum approaches as the audio screen will play an increasingly important role.

The audio-screen technique doesn't give the blind equivalent or even optimum access.

In the design of aids for the disabled, insights into the practical aspects of using special modifications (such as that gained by the tube analogy above) can provide programmers with a much better understanding of the problems they are trying to solve and can lead to design of much more effective special modifications.

Semitransparent Modifications

Hardware intervention is almost always necessary to achieve full transparency. Hardware intervention ensures complete transparency but comes at a higher cost. As a result, a number of strategies, termed *semi-transparent*, have also been developed to work with some but not all software.

Some of these techniques take the form of special software routines that are hidden in infrequently used portions of memory. Vectors within the operating system are reset to cause the computer to access special pointers instead of the normal keyboard-servicing routines. These pure software routines are often loaded from disk into the computer just prior to loading the standard program. In some cases, the routines may be automatically loaded when the computer is turned on. The individual can then use the special routine to select and run other programs.

The major drawback to modifications of this type is that they usually rely on pointers that may often be reset when more sophisticated or complex programs are loaded into the

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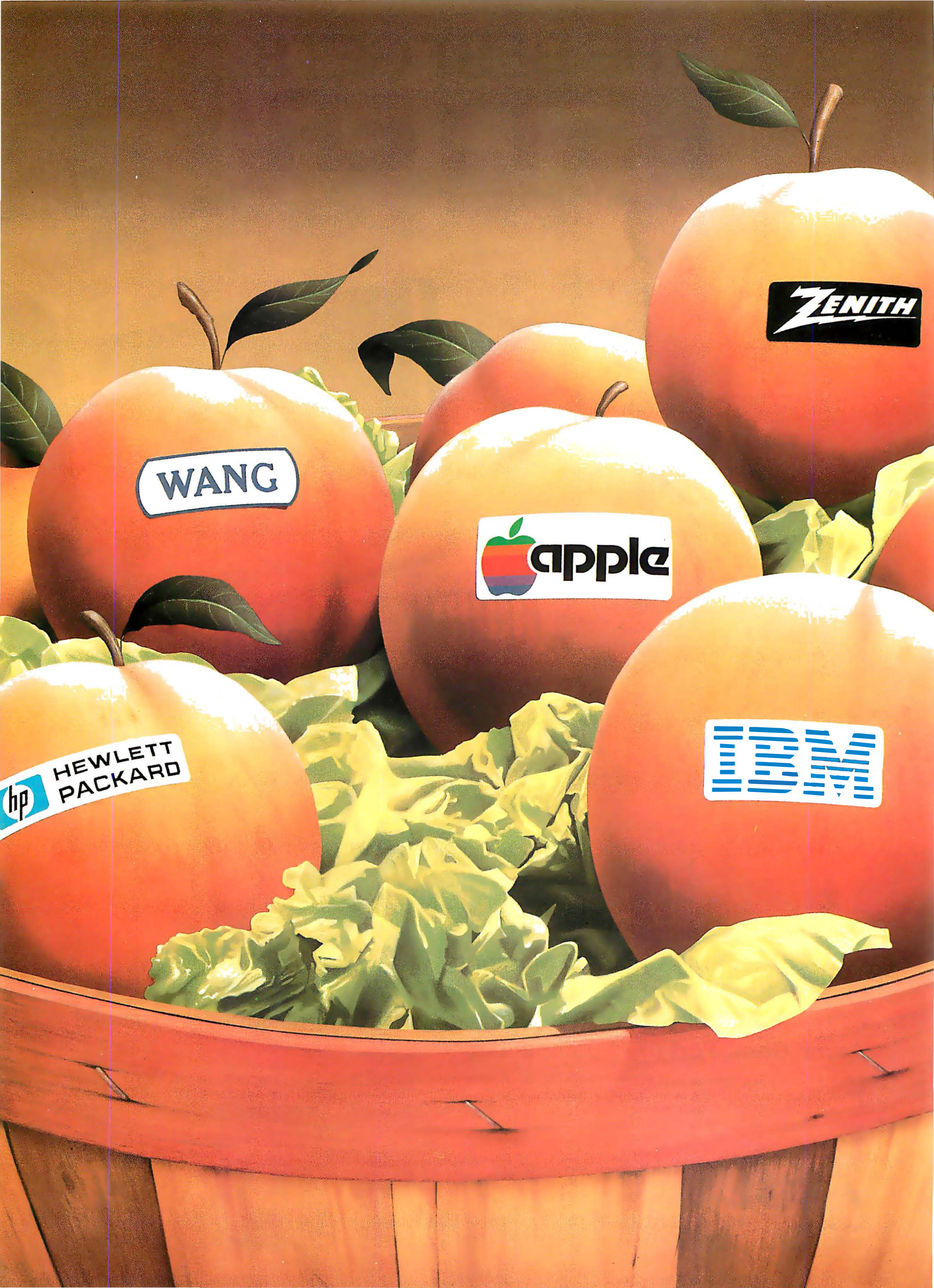
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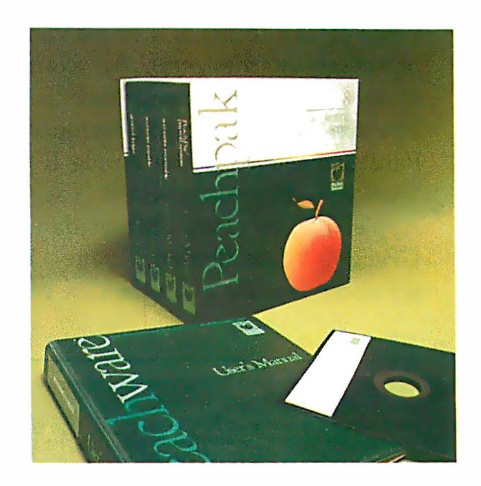
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computer. In addition, many of the more advanced programs consume all of the available memory space, totally wiping out such special programs. In some cases, special programs can be hidden in ROM (read-only memory), and special strategies can be incorporated that allow them to continually retake control of the computer even while more complex programs are being run. However, this approach again requires the use of at least some special hardware.

Examples of purely software modifications are the programs written by Peter Maggs at the University of Illinois, Champaign-Urbana (see reference 1) to provide a voice output of video-screen contents (using a variety of speech synthesizers). An example of the ROM-based approach is the adaptive-firmware card developed by Paul Schwejda for the Apple II (see "Adaptive-Firmware Card for the Apple II" by Paul Schwejda and Gregg Vanderheiden, page 276; see also reference 2). In the case of the adaptive-firmware card, the modification is essentially transparent to most programs except those that have critical timing loops around keyboard input routines (the adaptive-firmware card "steals" the microprocessor during these periods).

The SHADOW/VET voice-entry terminal for the Apple (by Scott Instruments) is another example in this category. The SHADOW/VET allows total control of the Apple using voice commands. Except for programs that involve critical timing loops around input routines, the SHADOW/VET can be used instead of the Apple keyboard for all operations even inside protected programs such as Visicalc. (Some keyboard use is necessary during initial voice programming of the unit.)

Multilevel Program Processing and Multitasking

In addition to the transparency problem, designers must understand two other concepts that are important to the development of many microcomputer-based assistive systems, particularly for extremely motor-impaired individuals. The first concept, *multilevel program execution,* refers to the ability of programs to be stacked so that the output of one program serves as the input to the next (for example, a special one-switch input program feeding a communication/spelling acceleration program feeding a standard text editor or other standard program). *Multitasking* refers to the ability to jump back and forth between different programs while keeping all programs active in memory in the computer at the same time (see reference 3).

The need for multilevel program execution stems from practical constraints in the development of programs for disabled individuals. If you had unlimited funds and time, you could develop a single program which contained all of the following:

- input routines (one-switch scanning, Morse code, optical headpointing, etc.)
- acceleration techniques (abbreviation expansion, word/phrase capability, word prediction, etc.)
- function programs (text editing, spreadsheet programs, games, educational programs, etc.)

Similarly, if all of the software were to be written by one group at one university (or company or rehabilitation center), then the software could be written in compatible modules that could simply be linked together to form the configuration desired by a given individual. Because neither of these proposals is practical, especially in light of the extreme variety of programs and functions that would be required on the third level, some type of program nesting is going to be required.

The need for multitasking can best be seen by first imagining an average person sitting at his desk, working on a problem, when the phone rings. He turns and answers the phone. The caller, a colleague, is asking for information for a project she's working on. While on the phone, the person pulls out a file, runs off some calcula-


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tions, and makes some notes based on feedback from his colleague. He then hangs up and goes back to his writing.

A severely physically disabled individual who uses an assistive microcomputer-based system would need a multitasking capability to accomplish this. First, he would have had to suspend what he was doing (without destroying it or waiting to update and store it) before answering the phone. While on the phone, he would need to access his information system, use his writing system to make notes, and use some computing capability before hanging up the phone and reentering the program he had suspended as the phone rang. During the process, he would need to enter and exit from several programs and routines without losing his place in any of them, thus requiring multitasking.

As with the multilevel program, this problem would not exist if it were possible to write a single, all-encompassing program for each individual. The program could then be written to allow suspension of activity and jumps from one section to another. This approach, however, would not allow the individual to take advantage of any of the standard software constantly being written and updated. It would also deny him access to the programs being used by his peers, as well as programs that may be necessary for him to access as part of his education or employment.

Approaches to the Multilevel and Multitasking Problem

Although current microcomputer operating systems do not allow multilevel and multitasking activities, more sophisticated operating systems are continually being developed. With the increasing memory and processor capabilities of the newer generations of microcomputers, designers can begin to consider the development of special versions of operating systems specifically designed to allow these types of multilevel and multitasking operation.

If the systems were configured to look like one of the many standard operating systems from the outside, they could in fact run standard pro-

grams along with special-function programs. At present, such "super operating systems" do not exist. Moreover, it would take a fairly high-capacity machine to successfully implement such a system. The bulk of the microcomputers being secured and supplied for disabled individuals today are of the much more limited variety. In addition, the software that the disabled individuals must access for their education or employment is also implemented on computers that do not have multilevel and multitasking capabilities. An alternate approach therefore is required that can be implemented now with the existing systems.

A Dual Central Processing Unit Approach

Although a true multilevel, multitasking capability is not currently possible on smaller computer systems, a reasonable approximation of one can be achieved using dual, nested computers. In this configuration, one computer would be used for the input and information acceleration programs as well as some special-function routines. A cable would connect this first computer to the keyboard (or keyboard emulator) on a second computer. The second computer would be used to run the standard software programs (the function-level programs).

Because the first computer would control the second computer through a keyboard emulator, any standard software programs could be run on the second computer without modification. At first glance, using two computers appears to be a brute-force solution; it is, however, the most flexible and straightforward method for dealing with many of the problems—and, in most cases, the *least expensive.*

Because the function-level programs would run on a separate computer, they would not require modification and could be written in any fashion and in any language. Because the entire first computer would be available for these programs, they could be written in a high-level language, thus lowering the cost to develop these special programs. Modifi-

cations of these special programs for specific individuals would be much easier, and complex input routines and data structures could be used to optimize the specific user's control and rate of input. This approach would also be much easier to modify and adapt over time to match the individual's changing abilities and needs (see reference 4).

If two identical computers were used in a dual, nested computer approach, the user would have a built-in hardware backup capability. If either computer went down, the other could be put into the input-level position. If the input-program package included some basic-function capabilities, the user would have at least a rudimentary system that could be used during the repair of the faulty computer or component.

It is more likely, however, that the two computers would not be identical. The system is designed so that the two computers do not need to be the same make, brand, model, or size. As a result, the first computer could be implemented on an inexpensive computer selected to provide only the capabilities necessary for the "first-computer" functions. This computer could then drive a much more expensive computer, which would be selected based upon the standard software programs the individual wanted to use.

In fact, the first computer could actually be used to control several different second computers in different environments (an Apple II at home, an IBM at work, and an Atari 400/800 when playing games with friends). In one system being developed at the Trace Center, University of Wisconsin, an Atari computer is being programmed to function as a high-speed, screen-based, optical, headpointing input system with abbreviation expansion and dictionary lookup capabilities. The system can then feed into a wide range of second computers (including IBM, Apple, and Radio Shack) using keyboard-emulator modules. In one case, the first computer (the Atari 400) costs less than many of the interface cards or accessories for the second computers. No matter which computer is chosen, the software availability for the first computer is not important, because it will be running only the special input routines. It is the second computer that would be selected to match the standard software packages desired by the disabled individual.

Conclusion

Microcomputers are providing existing rehabilitation engineering programs and firms with valuable new tools in the development of specialized communication techniques and aids. They are also opening up the rehabilitation engineering field to an entirely new group of individuals (programmers, etc.) who previously were unable to directly contribute due to the high overhead required in parts and equipment. Whereas work on custom electronic aids usually required that an individual be part of a research team at a center, practical solutions can now be created with little or no hardware components other than the standard microcomputer system and accessories. This is particularly true for special-function

Learning with Logo makes Logo come alive at home or in school

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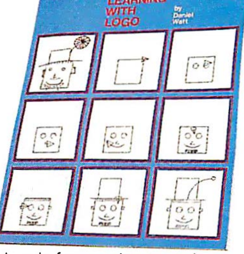
The book features detailed instructions for creating a Logo Procedures Disk (also available directly from the author) that contains sample programs and a number of ''tool procedures'' needed to carry out the projects in the book.

Daniel Watt has been involved in education as a curriculum developer, elementary school teacher, teacher trainer, and researcher. He worked for five years on a series of Logo research and development projects as a member of the MIT Logo Group. At present he is an editor with BYTE Publications and contributes regularly to Popular Computing *and* BYTE *magazines.*

Learning with Logo *is written specifically for users of the version of Logo developed at MIT for the Apple II® and distributed by Terrapin, Inc. and Krell Software, Inc. It contains appendices for users of Apple Logo® and TI Logo®.*

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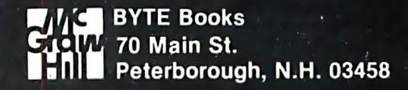
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programs developed to meet specific needs of disabled individuals.

The problem of providing transparent access to microcomputers (and thus allowing access to the vast world of standard software) usually requires some type of hardware intervention. With the advent of keyboard emulators and the use of dual, nested computers, even this activity promises to be returned soon to the more readily accessed and duplicated world of software. As a result, the immediate future promises to be an extremely exciting and productive period, which will see rapid advances in the development of both special-function programs and new strategies to ensure the complete access by disabled individuals to the world of microcomputers.

If this access can be assured, then the functional disabilities currently experienced by these individuals should decrease markedly as our society moves more and more into the electronic information age. If we *fail* to ensure access to our computer and information-processing systems for disabled individuals, our progress into the electronic information age will instead only present new barriers.

With good communication among the new group of individuals entering this field, the existing rehabilitation personnel, and most important, the disabled individuals themselves, the amount of truly useful software can be maximized and many existing barriers reduced. It may even be possible to effectively eliminate some disabilities in the same way that eyeglasses have eliminated what would otherwise be a visual handicap for many of us. A possible example of this would be the elimination of the writing handicap currently experienced by many persons with mild to moderate manipulative difficulties (due to a physical disability or severe arthritis) through the development of very effective and portable text-editing systems. Although initially writing speed might be slower, the incorporation of abbreviation expansion and other acceleration techniques would increase speed and give the added benefit of perfect penmanship.■

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3. Vanderheiden, G. V. "Practical Application of Microcomputers to Aid the Handicapped," *Computer*, January 1981.
4. *Proceedings, Fourth Annual Conference on Rehabilitation Engineering*, Washington, DC, 1981.

Further Reading

The Bulletin of Science and Technology for the Handicapped
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1515 Massachusetts Ave.
Washington, DC 20005

Closing The Gap
(newspaper on computers and the disabled)
Budd Hagen, Editor
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Communication Outlook
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A New Horizon for Nonvocal Communication Devices

Using the Panasonic Hand-Held Computer As a Personal, Portable Speech Prosthesis

Patrick Demasco and Richard Foulds
Tufts-New England Medical Center
171 Harrison Ave., Box 1009
Boston, MA 02111

Perhaps the greatest potential of personal computers is for people with severe physical disabilities. The power, flexibility, low cost, and availability of these machines make them natural tools for people whose physical limitations restrict their activities.

In this article, we will describe how to use the new Panasonic Hand-Held Computer (HHC) as a personal and portable communication device. We have focused on its use by individuals who have expressive communication impairments due to physical disabilities. Expressive communication includes all of the methods we use to make known our needs, concerns, and creative thoughts. The most obvious is the power of speech—something which most of us use as our primary means of communication. Other expressive skills, such as handwriting and typing, come into play as well.

Typical of those who may have communication impairments are large numbers of people with cerebral palsy. This form of brain damage occurs around the time of birth and results in a lifetime disability. A smaller group of people are communication-impaired as a result of amyotrophic lateral sclerosis (ALS, commonly known as Lou Gehrig's disease), which is a progressive neurological disease. Those who have suffered a stroke in the brain-stem area may also have communication impairments.

Single-purpose communication devices are effective but very costly.

In general, these people often cannot produce intelligible speech or legible handwriting. But it is important to note that communication impairments are not a reflection of cognitive abilities. Each of these people has normal linguistic and intellectual capabilities.

Alternative Communication

A great deal of work on behalf of people who have communication impairments has been done over the last decade, and several well-designed devices have been marketed for their use. Recently, the Apple II and the TRS-80 computers have been put to use as aids for the physically impaired. The growing interest in communication devices is undeniable; in the Johns Hopkins First Annual Search for the Application of Personal Computers and the Handicapped, 27 of 99 entries dealt with communication-device concepts.

A moderate number of dedicated, single-purpose communication devices have been built. These are typically microprocessor-based with some form of printout and display, and possibly a synthesized voice. Sizes, weights, and battery-life of the devices can be tailored to the needs of the disabled to aid in portability. They can be packaged to fit on a wheelchair and to withstand tests of rugged and continuous use.

But these devices have drawbacks as well. Their cost is necessarily high. Low-volume production cannot

About the Authors
Patrick Demasco is a research engineer at the Rehabilitation Engineering Center at Tufts-New England Medical Center. Richard Foulds is Assistant Professor of Rehabilitation Medicine and Director of Rehabilitation Engineering at Tufts-New England Medical Center.

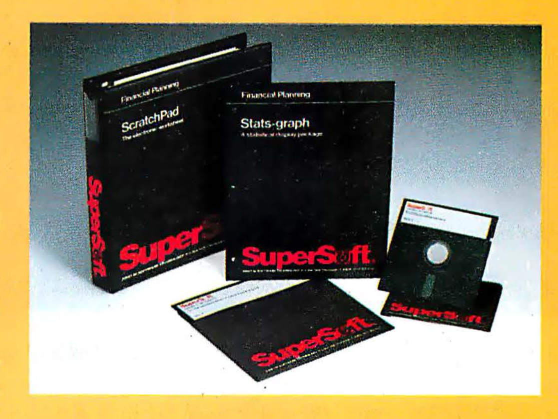
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The work in this paper has been supported at the Rehabilitation Engineering Center under Grant #G008200044 from the National Institute of Handicapped Research of the U.S. Department of Education.

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Photo 1: *The Panasonic Hand-Held Computer (HHC) along with some of the available accessories. The HHC is in the lower right. Clockwise, the accessories are the I/O driver, the RS-232C port, the additional 8K-byte RAM module, and the video/television adapter.*

possibly compete with the economics of large-run production. Distribution and service present additional problems. Products with limited use cannot support extensive field-service or local-service organizations. Repairs are often done at a central location that may be inconvenient for many users.

The personal microcomputer with its widespread availability offers an interesting alternative to single-purpose communication devices. Software communication aids are easily distributed on floppy disks that run on existing hardware. Thus the basic hardware cost is lower because of the economics of scale. By using standard microcomputer components such as game paddles, digitizing tablets, keyboards, voice recognizers, and so on, input to the personal computer can be configured to accommodate the existing abilities of the disabled person.

The personal computer's size is one drawback; mounting an Apple II on a wheelchair is impractical. And even if you did, it consumes too much power to be battery operated. While the personal computer is an excellent tabletop communication device and teaching aid, it does not meet the voice replacement requirement of the disabled person.

The Panasonic HHC

An article in BYTE (G. Williams and R. Meyer, "The Panasonic and Quasar Hand-Held Computers," January 1981, page 34) describing the new HHC marketed by both Panasonic and Quasar stimulated our interest. The computer seemed to be a bridge between the single-purpose portable communicator and the flexible, less costly personal computer. The HHC is portable enough to qualify for wheelchair mounting and is generally available at a reasonable price.

The Panasonic HHC represents a significant advance in personal computers. The system consists of a main unit with a 6502 processor, RAM (random-access read/write memory), ROM (read-only memory) monitor, ROM sockets, keyboard, liquid-crystal display (LCD), and an external bus connector. Additionally, there are several peripherals including an RS-232C interface, RAM modules, video driver, cassette interface, printer (only recently available), and modem (see photo 1).

Two or more peripherals can be attached to the main unit with the I/O (input/output) driver. If only one peripheral is used, then it can be connected directly to the main unit. You can create and run Microsoft BASIC (MBASIC) programs. The HHC can also run SNAP (a derivative of FORTH) programs. SNAP programs, however, must be written and debugged on a separate development system. The working program is then loaded into a PROM (programmable read-only memory) and executed in the HHC. The HHC's operating system is written in SNAP.

Our goal at the Rehabilitation Engineering Center at Tufts University, which focuses on technology as it relates to expressive communication, was straightforward: to see how close we could come to reproducing the valuable features of the single-purpose communication devices by using the Panasonic HHC.

Design Considerations

Engineers working on solutions to communication problems of disabled people must, of course, work around an individual's existing physical abilities to generate communication. In many instances the disabled person has sufficient manual coordination to touch a number of keys. If 27 keys can be conveniently reached, the entire alphabet and space bar can be used to make words. If more keys can be reached, their functions can be expanded to include common words or phrases. We call this one-to-one correspondence (one key for each entry) a *direct-selection method*. It is not much different from typing. Typically, in this case, a disabled person will use one finger or a headstick (a wand attached to a helmet) rather than all 10 fingers.

Sometimes, however, the desired vocabulary exceeds the number of keys or switches that can be easily pressed by the user. In extreme cases, only one switch may be accessible. For instance, the user's only controlled movement for purposes of activating a switch may be the kick of a foot. When the user has such a limited selection capability, an alternative presentation of the alphabet and vocabulary must be found.

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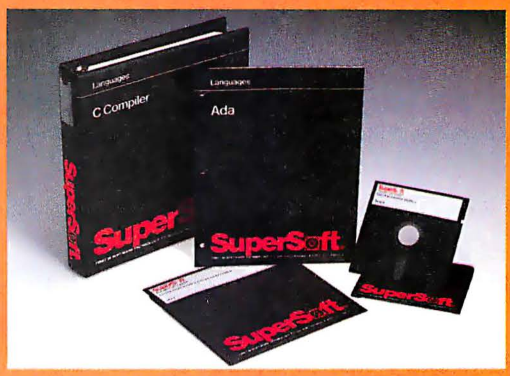
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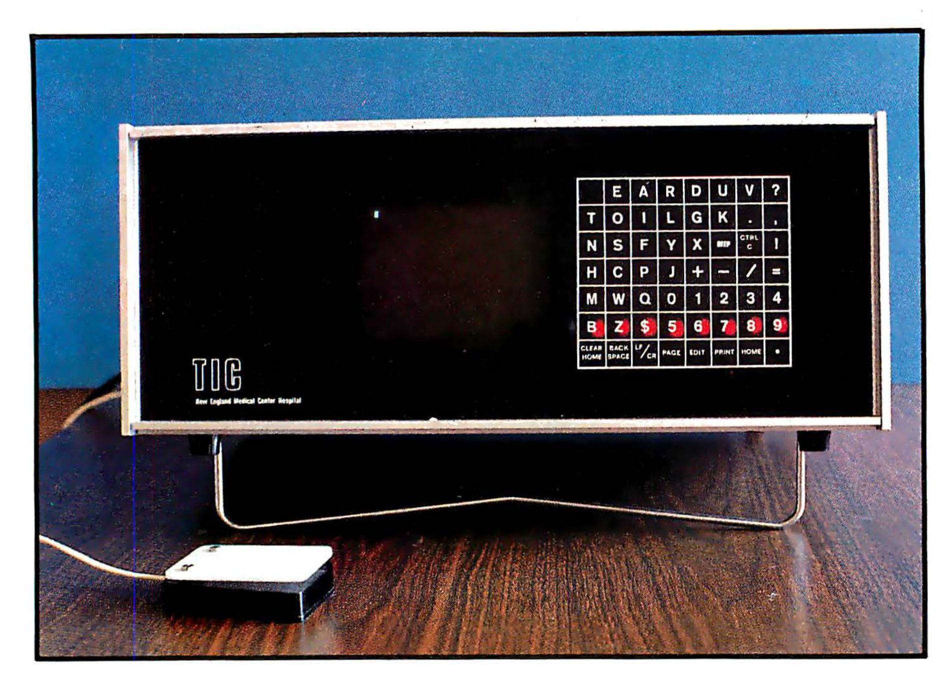


Photo 2: *The Tufts Interactive Communicator, developed in 1972, was an early scanning communication device. It employed all TTL circuitry and used a dedicated 5-inch monitor to display 1024 characters.*

In earlier work in our laboratory, we used the *scanning method* for a single-switch communicator. The Tufts Interactive Communicator (TIC) was a stand-alone, single-purpose device that presented the alphabet in a sequential fashion. The user faced a keyboard that had a back-lit array of seven rows of eight entries (see photo 2). The TIC highlighted the array row by row from top to bottom. The user selected a row by hitting a single switch. The TIC responded by then highlighting each entry in the row from left to right. The user hit the same switch a second time to choose an entry as it was offered. The chosen letter was then shown on an accompanying video display (32 characters by 16 lines).

Using the HHC

In developing the HHC as a communication device, we used both the direct-selection and scanning methods. Additionally, we worked within three design constraints. We would use commercially available components. No custom-fabricated circuits would be considered in the initial work. The purchase price for the components would not exceed $2000.

We purchased two additional pieces of hardware, a Votrax Type-'N-Talk for speech output and a digitizing tablet from Houston Instrument for use as an input device. All of our programs, which were written in BASIC, shared the following elements:

The purchase price for our communicator could not exceed $2000.

- User input: Each implementation has an input handler that recognizes some action of the user as a selection.
- Message array: The user's responses are directed to the selection of a character, word, or phrase. The arrangement of those units is called the message array. This array is generally a two-dimensional matrix whose units can be described with a row and a column number.
- Control selection: In addition to those units that are part of the user's message, additional units are designed to control functions necessary for the device to operate. For example, one unit in a system with speech output would correspond to a command to send the output to the voice synthesizer.
- Message buffer: When the user selects a message unit, it is stored in the message buffer. Many of the control functions (e.g., display) operate on this buffer.
- Message output: The message selected by the user is used to communicate with another person. Therefore, it is desirable to have a flexible output scheme that will closely imitate normal communication (e.g., speech output, printed copy).

We have developed three implementations of the HHC as a portable communication device: a scanning communicator, a direct-selection communicator using a keyboard, and a direct-selection communicator using a digitizing tablet. We will treat each of the three methods separately before returning to a general discussion.

The Scanning Communicator

Our first effort involved duplicating the function of the TIC on the HHC through a software emulation.

We needed hardware to display the 8 by 7 array of selections and to provide a single-switch input and a way to output the user's message. We used the LCD to display the array of selections. The major drawback to this implementation is that only one row of characters can be displayed at a time. (This was not a severe limitation, as we will explain later.) We used the entire keyboard of the HHC as the single-switch input so the user can hit any key (with a few exceptions) to signify a selection.

We used two output modes. For visual output, the LCD displays the user's message. The addition of a Votrax Type-'N-Talk provides synthesized speech of the user's message. The Votrax is connected to the HHC through the RS-232C peripheral. A printer would also be desirable, but that peripheral was not available to us when we wrote this article.

We used only one noncommercial piece of hardware in this configuration. Because certain keys on the

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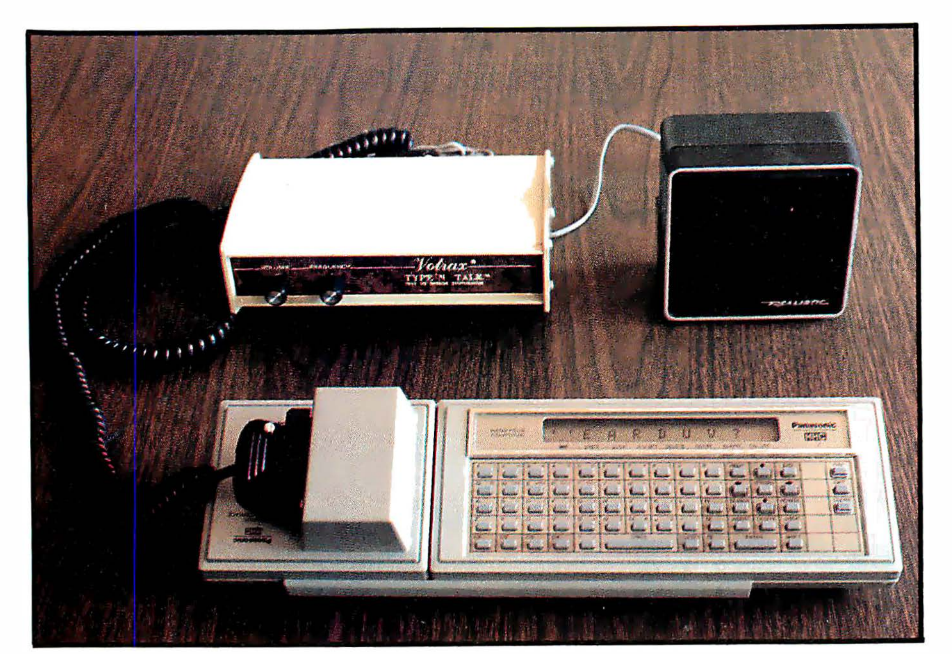


Photo 3: *The HHC when used as a scanning communicator (a latter-day TIC) uses the LCD to display rows of characters. The Votrax Type-'N-Talk and a Radio Shack speaker complete the communication device. A printer can also be added. (The first row of the TIC array is shown on the LCD.)*

2	3	4	5	6	7	8	9
3	4	5	6	7	8	9	10
4	5	6	7	8	9	10	11
5	6	7	8	9	10	11	12
6	7	8	9	10	11	12	13
7	8	9	10	11	12	13	14
8	9	10	11	12	13	14	15

Figure 1: *The scanning process moving from top to bottom and left to right provides faster access to certain locations. The numbers shown in this array signify the distance of each location from the start of the scan. Each time a selection is made, the scan starts over.*

HHC should not be hit as a user switch input (e.g., the Off key), we installed a Plexiglas guard on the keyboard. This guard also prevents possible damage to the HHC and angles the computer so the user can see the display more easily. The guard is easy to build (fabrication plans are available from the Tufts Rehabilitation Engineering Center). The scanning communicator is displayed in photo 3.

The HHC scanner operates as a row-and-column scanner. Two switch closures or key presses are necessary to select a unit. The HHC displays each of the eight rows in sequential order. When the user sees the desired letter or character on the LCD, he presses a key that selects the row. The chosen row remains on the LCD and the individual letters are highlighted from left to right by the cursor. The user presses a key again to select the single desired character. At this point the selection process is complete and that letter, along with any previously generated part of the message, is displayed on the LCD. If the message exceeds 26 characters, the most recent segment of the message is displayed. Then, following a short delay, the scanning process begins again at the first row.

Scanning is, of course, an inherently slow way of selecting messages. Because a sequence must be followed, some entries are near the beginning, while others fall near the end. It takes a great deal of time to reach those near the end.

In 1973 we had addressed this problem on the TIC by arranging the letters according to their frequency of occurrence in the English language. The accepted rank order is:

space e t a o n r i s h d l f
c m u g y p w b v k x j q z

The letter arrangement must combine the rank order with the procedure of scanning a two-dimensional array.

Because the scanner moves from top to bottom and from left to right, the upper-left entry is closest to the beginning of the scan. That entry, the first column of the first row, will be displayed more frequently during repeated scanning. The entry next to it is one step less frequent because it is in the second column, one step farther away. In this manner, we can count the number of steps to each entry in the array. If the upper left has a value of 2 steps (1 row plus 1 column), the next entry in that row has a value of 3 (1 row plus 2 columns) and the third has a value of 4 (1 row plus 3 columns). The first entry in the second row also has a value of 3 (2 rows plus 1 column), and the second entry in that row has a value of 4 (2 rows plus 2 columns). By placing the value of each entry in an 8 by 7 array, we can see a pattern emerging (see figure 1).

The entries that are equally as far from the beginning of the scan are located along diagonal lines. By taking the rank order of letters in English and placing them according to the best location on the array, we can obtain an optimal arrangement for scanning a keyboard (see photo 4).

When we compared our layout to similar 8 by 7 arrays that have been arranged alphabetically or in pseudo-typewriter fashion, we found our arrangement to be approximately 50 percent faster for the user.

To perform functions that are not part of the basic system operation, some of the units in the array are used as control selections. These are as follows:

SP (Speak): sends the entire contents of the message buffer to the Type-'N-Talk.
DS (Display): displays the contents of the message buffer.
CL (Clear): clears the contents of the message buffer.
<— Back (Backspace): moves the message cursor back one space.
<W (Backword): moves the message cursor back one word.

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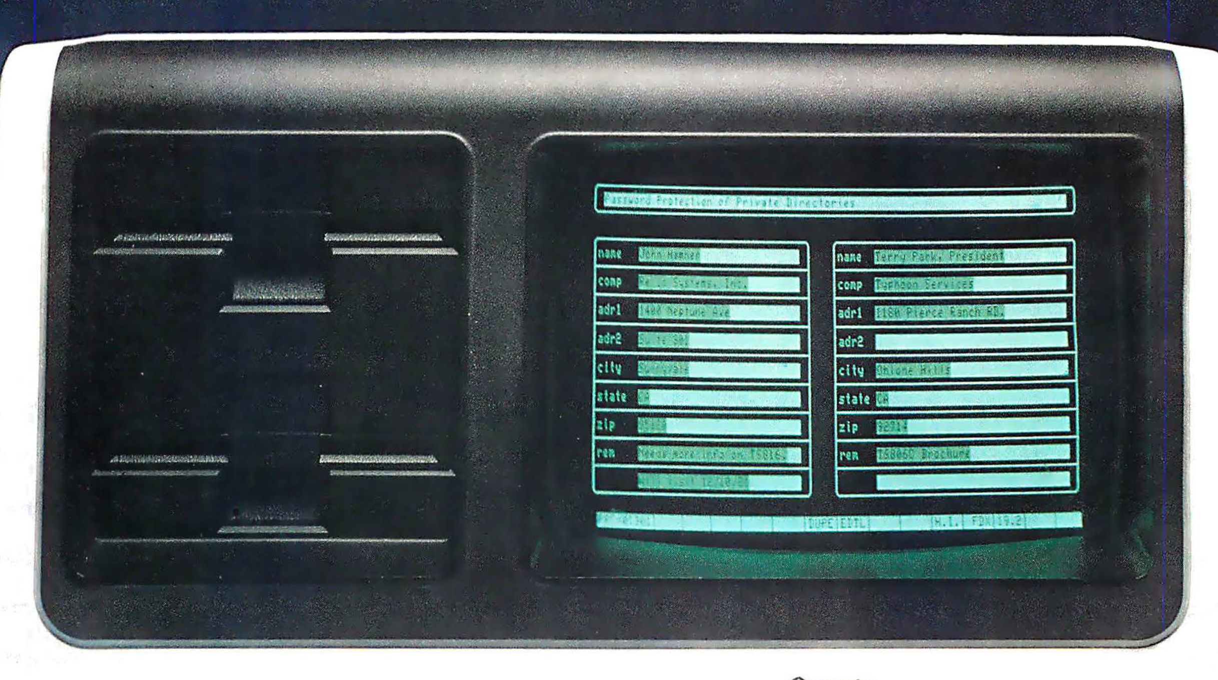
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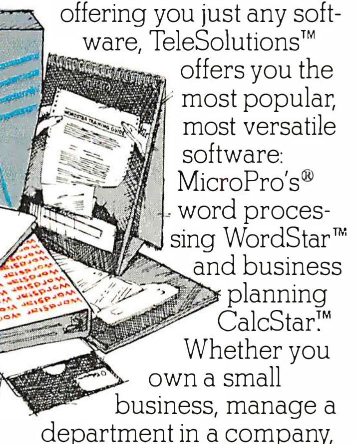
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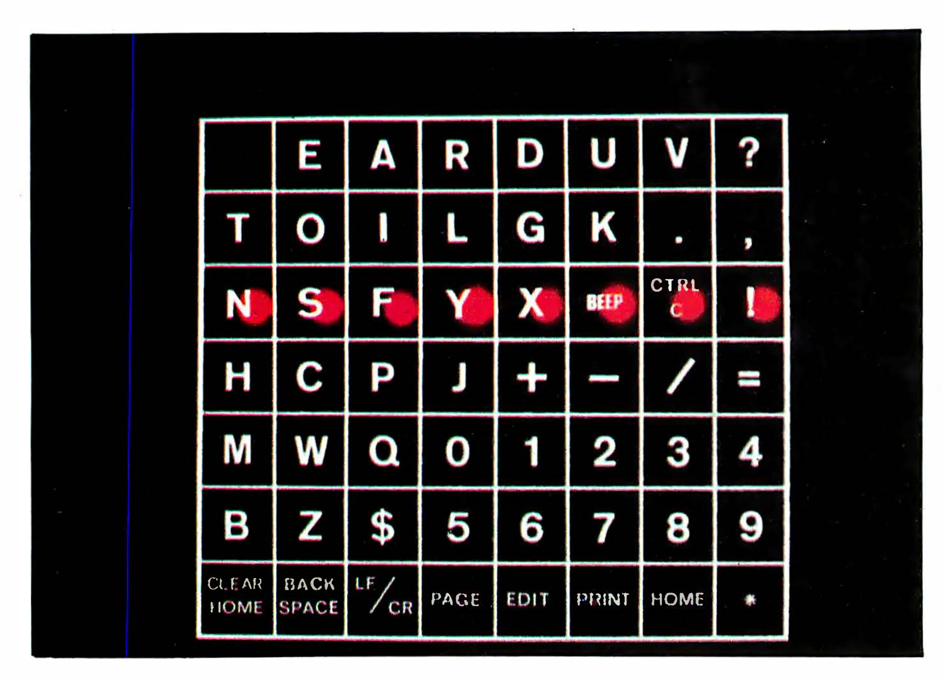


Photo 4: *The optimized scanning array of the TIC is arranged according to the frequency of letters in the English language.*

SR (Scan rate): allows the user to alter the rate at which information is displayed on the LCD. In the case of a disabled person, this control is essential to optimization of the user's performance.

BP (Beep): causes the HHC to make an audible beep. This allows the user to gain someone's attention easily.

The revised design we are now working on will include these improvements:

- User programmability: Including a user vocabulary makes a communication aid a personal device. The 8 by 7 matrix does not leave much room for user vocabulary after the basic alphabet and control commands are added. We have two alternatives: to make the array larger (e.g., 10 by 10) or to layer the scanner so that the user can switch levels. By offering a large number of selections, a programmable user vocabulary could greatly enhance the potential of this implementation.
- External switch: The keyboard as a switch is not an effective input scheme for every individual. Connecting an external switch through the RS-232C port (e.g., foot switch) could take advantage of the bodily movement over which the user has the most control.
- Anticipatory scanning: Rather than display the same 8 by 7 matrix to the user every time, it is possible to develop a scheme in which the device offers the user a choice based on his previous letter selection(s). For example, if the user selected "Q," the device would then display "U" as the first option. (The probability that "U" would follow "Q" is high). This scheme could significantly increase the efficiency of the device for the user.

Direct Selection Using a Keyboard

This configuration of the HHC is easy to do. Simply described, a direct-selection communicator uses the keyboard of the HHC for message entry. The necessary hardware is the HHC main unit, the RS-232C adaptor, and the Votrax Type-'N-Talk. Output is through the LCD and the Type-'N-Talk.

Because the keys on the HHC are much smaller and closer together than those on a conventional keyboard, we had to implement a keyguard. We designed one to fit over the HHC keyboard that would help prevent the user from making false entries that could impede the communication rate. Initially, we attempted to use Plexiglas, but we found that the drilling necessary to make the sheet fit the square keys of the HHC was extremely difficult.

Finally, we used the telecomputing overlay that comes with the RS-232C peripheral. This is a thin vinyl die-cut overlay that fits over the keyboard and changes the legend to the equivalent of a teletypewriter keyboard. The overlay was originally designed to fit so that the keys would stick through and project above it. Our modification used ⅛-inch-thick double-stick tape placed between the rows of keys. We placed the overlay on the tape to elevate it to a level even with the top of the keys.

The HHC now has a flat surface. When a finger hits between two keys, neither key is pushed, because the overlay, supported by the double-stick tape, cannot move. When a key is hit directly, the vinyl dimples down and allows the key to be pushed. This modification provides a workable keyguard without expensive alteration.

To operate this device, users type a message at the keyboard. As they type, entries appear on the LCD of the main unit. The assignable-function keys serve as command units to enable them to output the message to the voice synthesizer and clear the message buffer. The drawback to this implementation is that the keyboard is small and many disabled individuals might have difficulty making accurate selections despite the presence of a keyguard.

Direct Selection Using a Tablet

The usefulness of the direct-selection communicator is restricted by its small keyboard. To overcome this limitation, we decided to use a digitizing tablet from Houston Instrument as an input device.

The digitizing tablet has an 11.5-inch-square active area and outputs the coordinates of the cursor through an RS-232C port. The device has several operating modes that include single-point digitization and continuous digitization. The tablet is easily connected to the HHC with the

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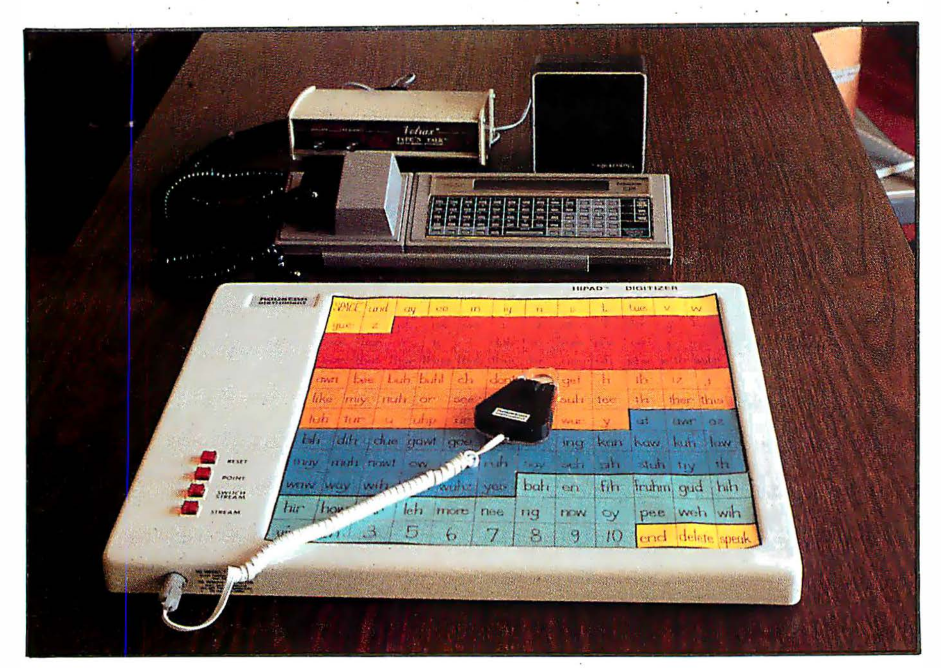


Photo 5: *A Houston Instrument Digitizing Tablet is added to the HHC and Type-'N-Talk to allow for an expanded and flexible keyboard.*



Photo 6: *Jim Viggiano, a nonvocal consumer consultant at Tufts–New England Medical Center, demonstrates his method of communicating using his index finger on the language board. The keyboard arrangement is the WRITE-400 system of language clusters.*

RS-232C peripheral. Message output is accomplished by the LCD and the Votrax Type-'N-Talk. This configuration appears in photo 5.

A 12 by 12 matrix of character and word selections is overlaid on the digitizing surface. To operate the tablet, the user holds the digitizer pen and touches the desired unit, which appears on the LCD for user verification. A potential for greater communication rates exists because the user does not have to wait for the selection to appear as in the scanning system. He only has to pick it out of the array by touching the tablet. Naturally, the user of this device must have greater motor control.

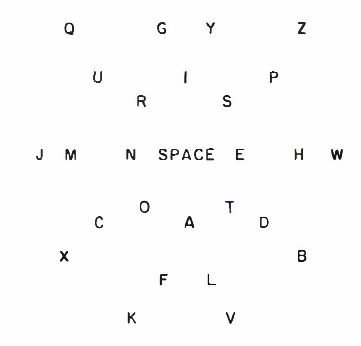


Figure 2: *An optimized direct-selection arrangement for the alphabet using the relative frequency of letters to place them in concentric circles around the space.*

We decided on a 12 by 12 arrangement, but that is only one of many possible layouts. The digitizing tablet has a resolution of 100 targets to the inch. Under software control it is possible to select layouts that include small or large targets and even arrays of targets with mixed sizes and shapes.

The same sort of array-optimization scheme that we used in the scanning method can also be used in direct selection. The typical disabled person may use only one finger or a headstick, so the standard typewriter layout is inefficient. Because a space is the most commonly used "character," it can be located in the center of the keyboard. An optimized keyboard design can be completed by arranging the characters around the space in concentric circles or squares. The more frequently used characters will be placed closer to the center. Figure 2 provides an example of this implementation for an 8 by 7 array.

The designer of any communication system must choose the characters, words, or phrases that will appear in the array. While this choice of units is dependent on many things, the most important factor is the size of the array. The scanning-communicator array was not much larger than the size of the alphabet. In the direct-selection tablet communicator the array is 144 elements, which gives us much greater flexibility in our choice of units. Instead of an alphabet and word scheme, we chose the WRITE system, developed at the Rehabilitation Engineering Center by

Dr. Cheryl Goodenough-Trepagnier. It consists of a statistically derived list of the most commonly occurring letter clusters in the English language. (Photo 6 shows the language clusters on the digitizing tablet.)

The rationale for this system is that it provides a set of language units that will produce all English words by means of the lowest possible number of selections. For example, in an alphabetic system the average number of selections per word is 5; in a WRITE-400 system, the average number of selections per word is 1.54.

The control selections implemented on the direct-selection communicator include all that were used on the scanning communicator, with the exception of the scan rate.

Of the many ways to improve this system, user programmability is probably the most significant enhancement that can be made. Because the direct-selection implementation has a much larger array than the scanning communicator, an individualized user vocabulary is a more desirable feature. In addition, programmability would enable the user to select the size of the array. The array size is ultimately dependent on the user's motor-control ability. Because individual abilities vary significantly, no single configuration can optimize every user's communication speed.

BASIC Implementation

We wrote all three implementations in the supplied MBASIC language using information from the HHC's reference manuals. (See listing 1 for the scanning configuration program.) Along the way, we discovered it was not possible to use the INPUT or GET commands to look at the keyboard because both of those commands wait for an input before proceeding to the next command. With a scanning arrangement, the display must be changing while the device waits for an input. Therefore, to implement a keyboard scanner we had to use the keyboard buffer. The keyboard-buffer pointer will change any time a key is depressed. In the program in listing 1, PEEK(518) represents the value of this pointer.

There is a major disadvantage to

Listing 1: *MBASIC program for the scanning configuration of the HHC.*

```
5    REM DATA FOR DISPLAY ARRAY
10    DATA "'  '"," E "," A "," R "," D "," U "," V "," ? "
15    DATA " T "," O "," I "," L "," G "," K "," . "," , "
20    DATA " N "," S "," F "," Y "," X ","BP ","SR "," ! "
25    DATA " H "," C "," P "," J "," + "," - "," / "," = "
30    DATA " M "," W "," Q "," 0 "," 1 "," 2 "," 3 "," 4 "
35    DATA " B "," Z "," $ "," 5 "," 6 "," 7 "," 8 "," 9 "
40    DATA "CL ","<- ","<W ","SP ","DS "," * "," ( "," ) "
45   REM DATA FOR MESSAGE DISPLAY ARRAY
50    DATA " ","E","A","R","D","U","V","?"
55    DATA "T","O","I","L","G","K,"".",","
60    DATA "N","S","F","Y","X","11","12","!"
65    DATA "H","C","P","J","+","-","/","="
70    DATA "M","W","Q","0","1","2","3","4"
75    DATA "B","Z","$","5","6","7","8","9"
80    DATA "13","14","15","16","17","*","(",")"
85    DIM A$(8,7),B$(8,7)
90    ATTACH 70 TO #2
95   REM
100 REM  EXECUTABLE CODE
105   GOSUB 555
110 REM
115 REM  THE FOLLOWING CODE LOADS THE TWO ARRAYS
120 REM  A$ AND B$ WITH DATA
125  FOR I=1 TO 7
130  FOR J=1 TO 8
135  READ A$(J,I)
140  NEXT J,I
145  FOR I=1 TO 7
150  FOR J=1 TO 8
155  READ B$(J,I)
160  NEXT J,I
165 REM
170 REM  THE FOLLOWING CODE WILL EXECUTE A ROW
175 REM  SCAN AND TESTS FOR A KEYBOARD ENTRY
180  XLAST= PEEK(518)
182  PRINT
183  PRINT BUF$
185  FOR I=1 TO 7
195  FOR J=1 TO 8
200  PRINT A$(J,I);
205  NEXT J
210  PRINT
212  IF PEEK(518)<>XLAST GOTO 240
215  NEXT I
220  GOTO 185
225 REM
230 REM  THE FOLLOWING CODE EXECUTES A COLUMN
235 REM  SCAN AND TESTS FOR A KEYBOARD ENTRY
240  YLAST=PEEK(518)
245  PRINT
250  FOR J=1 TO 8
255  PRINT A$(J,I);
260  FOR L=1 TO WAIT
265  NEXT L
270  IF PEEK(518)<>YLAST GOTO 315
275  NEXT J
280  PRINT
```

Listing 1 continued on page 182

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developing flexible input schemes from a BASIC-based system: the keyboard buffer is the only HHC device that can be programmed easily from that language. Unfortunately, the status of peripheral devices such as the RS-232C interface is hidden from BASIC. Because the peripheral devices lie in the same address range as the MBASIC ROM, you must switch banks to access those peripherals. This can be done only from a SNAP program.

Realizing Full Potential of HHC

We believe communication aids can be successfully developed on the HHC through the use of SNAP. In addition to SNAP's greater accessibility to the HHC's unique memory architecture, it offers the advantage of greater execution speed and smaller memory requirements.

Although you will never be able to program directly in SNAP on the HHC, a SNAP-based development system on the market includes emulation software to run on an Apple II. This development system (available from Friends Amis Inc., 505 Beach St., San Francisco, CA 94133) allows the programmer to create and debug programs on the Apple II and then to burn PROMs that are placed inside the main HHC unit. Because the Panasonic machine does not have a disk storage system yet, PROMs are an ideal storage system.

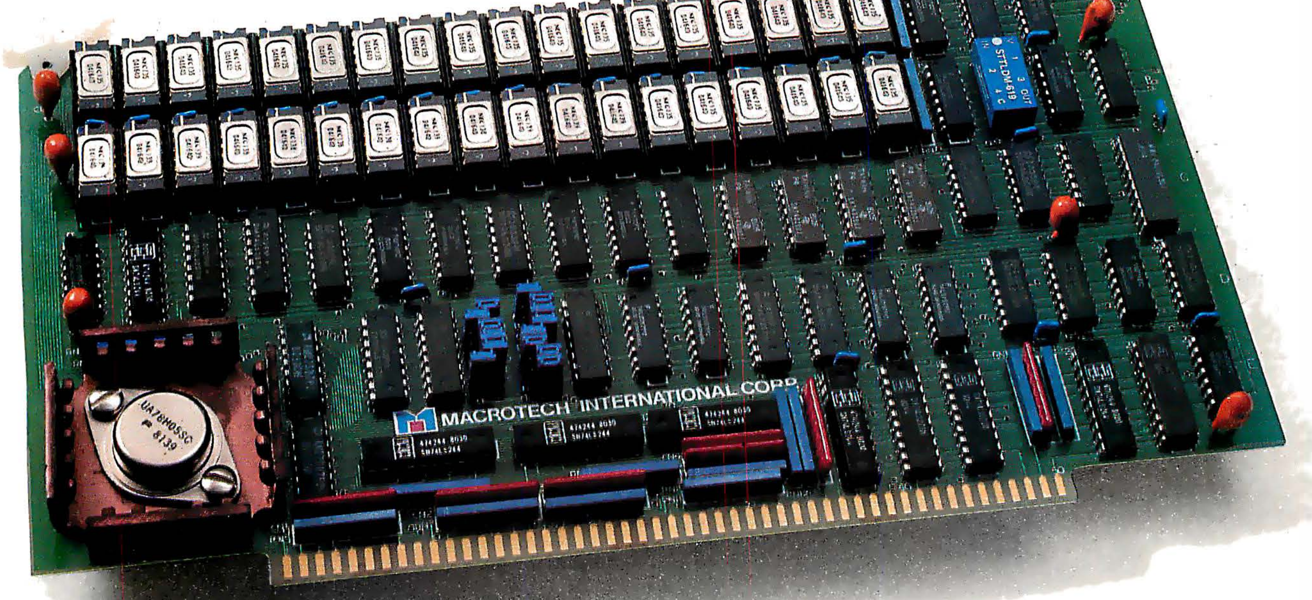
Using a SNAP-based system would also make way for the expansion of the HHC's usefulness to the disabled individual. We are now focusing on having the HHC operate in two modes. The first mode, which has been the topic of this article, is the operation of the HHC as a personal communication device. The second mode would incorporate the three input strategies (e.g., scanning) into the actual operation of the HHC. This mode would give the disabled individual an opportunity to operate the HHC as a personal computer. This strategy clearly presents the greatest potential for using a personal computer as a rehabilitation aid and comes closest to our ultimate goal of eliminating the need for special-purpose devices. ■

Listing 1 continued:

```
285  GOTO 245
290 REM
295 REM THE USER HAS MADE A SELECTION
300 REM THE FOLLOWING CODE DETERMINES IF IT WAS
305 REM A CHARACTER OR A COMMAND.  IF IT WAS A
310 REM CHARACTER THEN THE MESSAGE IS DISPLAYED
315  IF LEN(B$(J,I)=2 GOTO 355
320  BUF$=BUF$+B$(J,I)
325  N=N+1
335  GOTO 180
340 REM
345 REM THE FOLLOWING CODE EXECUTES THE COMMAND
350 REM SELECTIONS
355  COM=VAL(B$(J,I))-10
360  ON COM GOSUB 375,515,400,450,470,435,420
363  PRINT
365  GOTO 180
370 REM BEEP(BP) SUBROUTINE
375  FOR I=1 TO 5
380  PRINT CHR$(7)
385  NEXT I
390  RETURN
395 REM  CLEAR SUBROUTINE
400  BUF$=""
405  N=0
410  RETURN
415 REM  DISPLAY SUBROUTINE
425  RETURN
430 REM  SPEAK SUBROUTINE
435  PRINT #2;BUF$
440  RETURN
445 REM  BACKSPACE SUBROUTINE
450  BUF$=LEFT$(BUF$,N-1)
455  N=N-1
460  RETURN
465 REM  BACKWORD SUBROUTINE
470  C$=RIGHT$(BUF$,1)
475  IF C$=" " GOTO 505
477  IF C$="" GOTO 505
480  BUF$=LEFT$(BUF$,N-1)
495  N=N-1
500  GOTO 470
505  RETURN
510 REM  SCAN RATE CHANGE SUBROUTINE
515  XLAST=PEEK(518)
517  PRINT
520  FOR I=1 TO 10
525  PRINT I;" ";
527  FOR L=1 TO WAIT
528  NEXT L
530  IF PEEK(518)<>XLAST GOTO 550
535  NEXT I
540  PRINT
545  GOTO 517
550  POKE 535,I
555  WAIT=145+(PEEK(535)*200)
560  RETURN
565  END
```

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Minspeak

A semantic compaction system that makes self-expression easier for communicatively disabled individuals.

Bruce Baker
840 Rolling Rock Rd.
Pittsburgh, PA 15234

Minspeak is a new language prosthesis designed for disabled people who cannot express themselves through speech or hand signs. It is a semantic interface that uses microprocessor technology in a radically new system of communication that reduces the time and effort required for self-expression.

A person using a Minspeak board with fewer than 50 keys can produce thousands of clear, spoken sentences with fewer than 7 strokes. Minspeak users don't even have to know how to spell; they can produce complete sentences without selecting letters, phonemes, or words. The unique Minspeak process permits the user to translate thought into speech.

Minspeak has a modern linguistic coding system based on general ideas underlying human communication. The coding technique uses sequence to define context, thus exploiting the human mind's ability to process semantic information. Easy-to-understand symbols on each key represent ideas. The meaning of each key image changes according to the sequence in which it is hit. By combining these symbols, whole spoken sentences can be generated. The simplicity or complexity of the symbols will depend on the needs and abilities of the user.

The best way to explain how Minspeak can do all of this is to start with the reasons behind its existence.

Research and Insights

Several years ago, as research for my dissertation, I set out to study the attitudes of able-bodied people toward people with obvious physical disabilities. To do the research, I needed to speak to disabled as well as able-bodied individuals. The most interesting and insightful group of people I met had cerebral palsy. Ironically, the condition which caused them to have these insights also prevented them from being able to express those insights easily. Communication was slow and inconclusive. Unless you have had some personal experience with severe physical communication disabilities, you may not fully realize what slow and inconclusive means in this context.

One man I met can communicate only with the aid of an IBM Selectric typewriter. His lack of voluntary muscle control, stemming from a birth injury, precludes not only hand signs and speech but also a reliable eye blink for Morse code. He expresses himself by pushing down on a board with his chin. This signal is in response to the presentation of letters on a revolving metal disk. The disk pauses for two seconds to position each letter in front of a stationary arrow. When he sees the letter he wants, he presses the board with his chin, and the letter is typed. This method is slow and tedious. Creating the word "can" requires two and one half scans of the entire alphabet, and a single sentence often takes 30 minutes to complete.

Another man uses a communication system based on eye motion. A movement of the eyes upward and to the left indicates yes, while a movement downward and to the right means no. In this system, the conversational partner performs the functions of the revolving disk. As I slowly recited the alphabet, he signaled his

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About the Author

Bruce Baker did his undergraduate and graduate work in Greek and Latin at Wabash College, Indiana University, and the University of Paris and has taught widely in the United States and Europe. Currently, he is a doctoral candidate in French and Spanish at Middlebury College and Consulting Linguist to the Prentke Romich Co. in Shreve, Ohio. Last year he was named Contributing Editor to Communication Outlook, *a publication of the Artificial Language Laboratory of Michigan State University.*

A Communications Impasse

The communicatively disabled constitute a group for whom access to microprocessors could mean a real revolution, and a common assumption is that recent technological advances have produced the necessary communication aids. Unfortunately, this is not the case, but the problem does not lie in the new technology.

Neurological damage sufficiently extensive to hamper intelligible vocalization is regularly accompanied by difficulty in control of physical movements. To use any communication aid, the user must be able to actuate some type of switch. Consequently, existing communication systems do not solve the basic human-engineering problem of transferring information from the mind of the communicator to the communication aid, because all systems for complete communication, voiced or unvoiced, have been based upon actuating letters, words, word parts, or phonemes (minimal sound units).

Magnetized or light-sensitive keyboards, new scanning methods, and eye-tracking systems can make the selections easier, but still cannot reduce the number of selections required to communicate whole thoughts.

A nonspeaking person with cerebral palsy faces the task of accessing between 30 and 40 keys to produce a single sentence. A neurologically impaired person able to make one selection every five seconds requires many minutes of intense concentration and labor to produce a single statement.

The normal response time in conversation is less than three seconds. If someone is forced to wait 10 seconds for a reply, anxiety results. If a person is forced to wait five minutes, communication falters; conversation becomes impossible.

If letters are too slow, what about words? Sadly, systems based on actuating words are too extensive and ironically too restrained. The more words there are, the longer it takes to scan through them. Imagine going one by one through 200 words. Even being able to jump through them five at a clip requires an enormous amount of time. And yet 200 words is really a small vocabulary.

If direct selection is physically possible for the user, imagine a board with 400 words. The huge size of such a board, the smallness of the individual squares, and the intellectual complexity of remembering locations of words present obvious difficulties.

Coding can reduce the size of a word board and increase the available vocabulary. A three-number sequence can address up to 999 words, but the human memory requirements are staggering. "What is word 643? Is it 'potato'? No, that's 512." The average person uses thousands of different words every day. And even if the word board could contain most of a user's vocabulary, a simple sentence like "Are you going to the store today?" would require the user to select 7 codes by hitting 21 keys. Research has shown that most people who have tried to use fixed-word boards return to alphabet-spelling boards.

What about a hybrid system that mixes words, letters, and word parts? Photo 1 shows a person using such a system, which he actuates with a headstick. The board has more than 100 squares, each inscribed with a letter, word, or word part. (The word parts are morphemes, un-, -ed, -ly, or frequently used letter combinations, -th, -wh, -tion, -ize.) This approach is an improvement but, like the others, is still very slow. An average sentence requires in excess of 20 actuations. To get the number of actuations below 20, the board would have to have more than 400 keys. By combining the demand this would make on human memory with the considerable effort required to make a single key selection, it becomes obvious that communication on these systems demands considerable effort from sender and receiver.

A system based on letters is not the answer, and one based on words is worse. A mix of words and letters affords some relief, but not enough. People with communications disorders simply need more "bang to the punch" if they are going to be able to exploit the computer's potential for equalizing physical differences.

The source of the difficulty seems to lie outside the realm of technology. The very nature of the alphabet is at the heart of the problem. The quantity of information borne by a single letter is quite small. Information transfers conducted in such small units will necessarily require many units. Biomedical engineering cannot change this. Perhaps a semantic approach can.

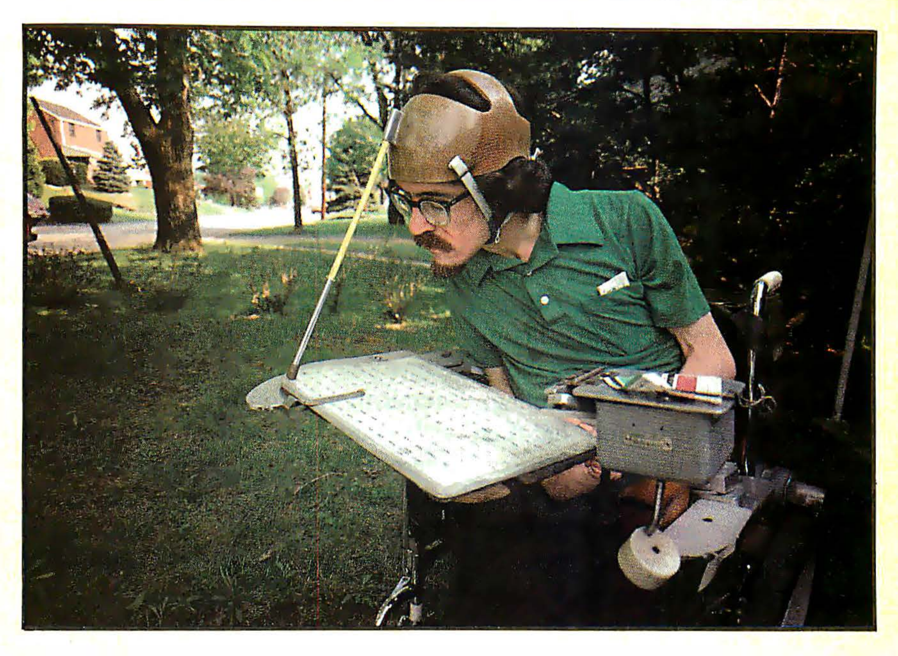


Photo 1: *Hale Zukas has cerebral palsy and uses a communication board and headstick of his own design. A Phi Beta Kappa graduate in mathematics from the University of California at Berkeley, he is one of a group of highly skilled communication-aid users whose cooperation and insights into Minspeak have been indispensable.*

letter choice by making the "yes" eye movement. Although we divided the letters of the alphabet into separate groups of vowels and consonants, and further divided the consonants into those before and after "L" for easier reference, this system is still terribly slow and very limited.

For him to ask the simple question "What did you say?" requires a dozen scans through the alphabet and many questions to establish whether a word is ending or a new word is beginning. The degree of concentration that this system demands of the conversational partner is so great that my friend often lets many misunderstandings pass just to get the central message across. I often wonder if I have understood his message correctly or if my friend feels that the correction isn't worth the time and effort required to make the meaning clearer.

The inability to express oneself is one of the most widespread and catastrophic disabilities. According to a report from the University of Wisconsin's Trace Research and Development Center for the Severely Communicatively Handicapped, as many as 500,000 people in this country are unable to communicate either vocally or with standard hand signs. The causes are numerous, but among the most common are cerebral palsy, strokes, amyotrophic lateral sclerosis (Lou Gehrig's disease) and vehicular head trauma. One family in four is at some time touched by a serious communication disorder.

Because hundreds of thousands of these people have unimpaired cognitive abilities, the need for easy communication methods becomes all the more important. As the realities of physical communication disorders became apparent to me, I decided to focus my research on finding some means of facilitating nonvocal communication.

Addressing the Need

Minspeak began as a simple remedy to a single aspect of nonvocal communication needs, the problem of feedback—called phasis in linguistics. Sentences that check the channel of communication between sender and receiver serve a phatic function.

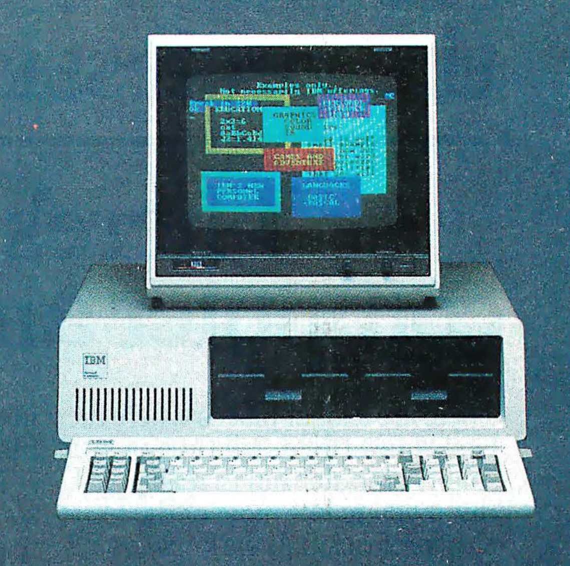
In face-to-face conversation, speakers need to be assured either through verbal or body language that the message is getting through. Because the listener is aware of this, he nods, makes sounds such as "unhuh,hmm" or says "yes, I see." If the message is complex or the speaker is anxious, the speaker may request additional phatic signs by saying "you know" or mentioning the receiver's name. When a person has a severe physical communication disorder, phatic problems take on a pressing importance for both conversational partners.

Able-bodied speakers have a wide range of vocabulary and syntactical phatic strategies at their disposal. In principle they can generate an infinite number of different phatic sentences, but they do not. Instead, the same phatic utterances are used again and again. A limited number of responses meets the five basic phatic needs most people experience in conversation. They are:

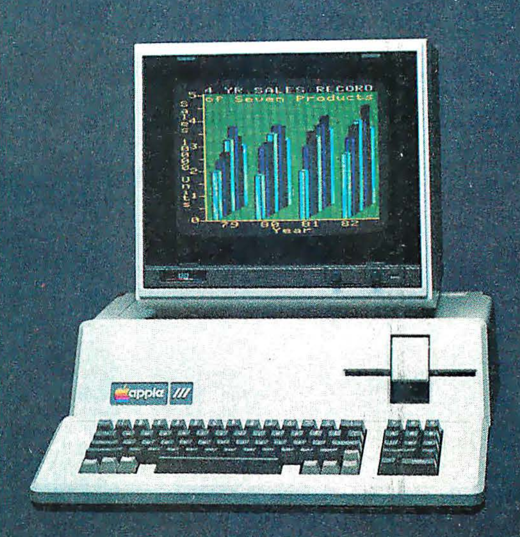
1. To ascertain the quality and quantity of the information being received at the other end of the communication channel. (Am I being heard? Is my meaning comprehended?)
2. To learn whether the information, once understood, is being judged correctly or erroneously. (Am I right, Joe?)
3. To determine how the transmitted information is affecting the emotions of the receiver. (Doesn't he care the article is late?)
4. To estimate how the transaction is affecting the receiver's opinion of the sender. (I won't tell her that; I'll sound so stupid.)
5. To collect information about what's going to happen in the immediate future concerning: (a) the duration of the conversation, (b) possible topic shifts, (c) eventual results of the interaction.

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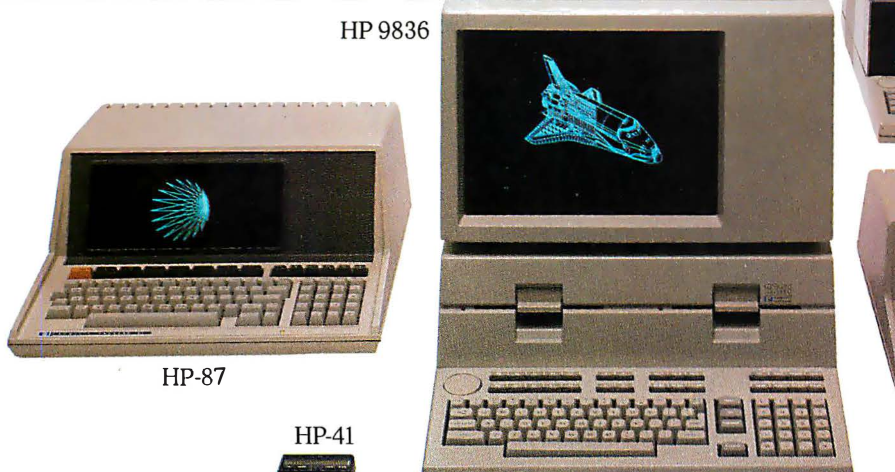
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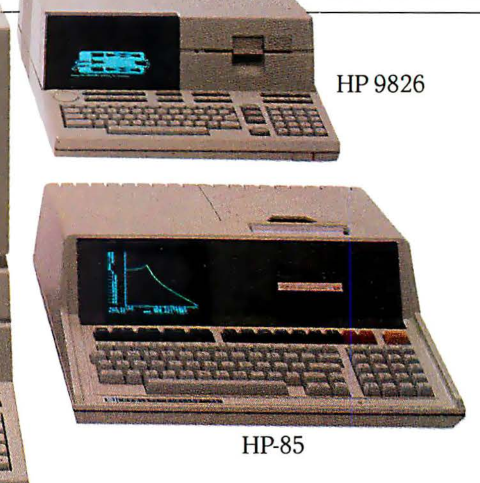
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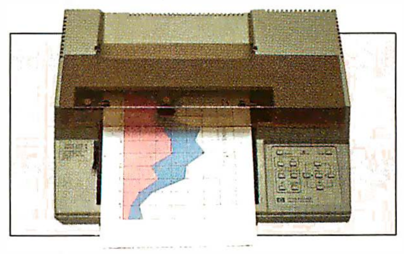
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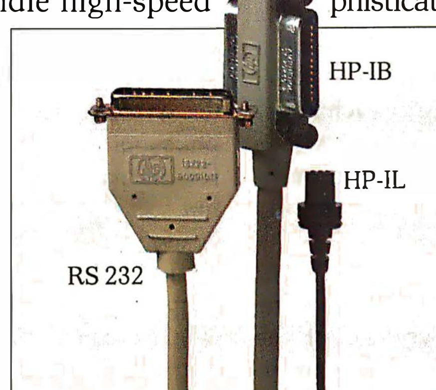
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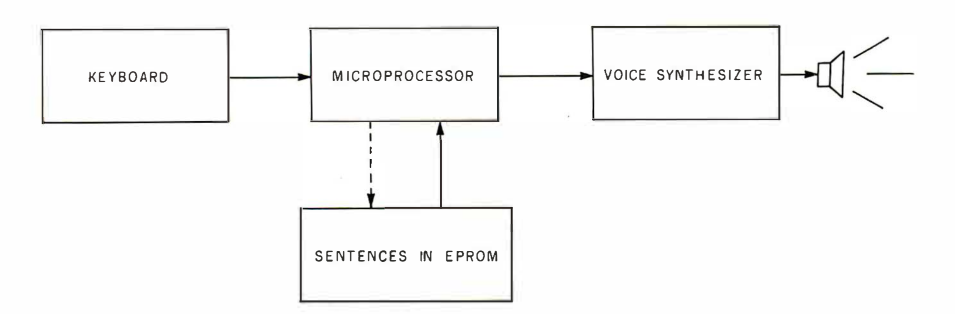


Figure 1: *The bulk of the Minspeak's memory is erasable programmable read-only memory (EPROM). The voice synthesizer used in the first prototype was the Votrax SC-01.*

I prepared 26 sentences to satisfy these phatic needs. The simplicity of implementation can be illustrated with the rotating-disk communication system. English sentences do not begin with question marks, so I decided to use them to designate the beginning of a phatic comment. Each of the 26 sentences is written on the user's lap tray and marked with a single letter. He can communicate an entire sentence by hitting the ? key and a letter. The receiver then consults the lap tray to see which sentence corresponds to the letter. For example, when the user selects ?G, the receiver can look at the lap tray and read "I'm pleased by what is being said."

These sentences facilitated conversations on a number of different silent systems and had the potential of being even more effective if they could be generated on voice-synthesis equipment. If phatic sentences could be designed context free and reusable, so could other sentences. The success of the phatic experience could be applied to the rest of the communication process.

If users of communication aids had at their disposal a collection of several hundred multipurpose sentences, all sorts of routine but important transactions could be made easier for them and for their associates. If users could access these sentences through short codes, communication could be conducted almost at the speed enjoyed by able-bodied speakers.

Taking It One More Step

The redundant character of daily speech as seen in the phatic project became a primary concept of a new system for communication. I called it Minspeak, a parody on the "newspeak" in George Orwell's *1984*, with the Min for minimum. My first task involved constructing thousands of sentences that were reusable and appropriate for most daily situations.

I designed short codes to access these sentences through a radical alteration in the representational information of an alphanumeric keyboard. Instead of letters, the keys bear images taken from daily life. These images stand for concepts rather than words. Some symbolize linguistic functions, some the activities of daily life; others denote styles of speech and mood.

Users can easily remember a large number of sentence sequences.

Most important, each key has a range of significance, including a function, several activities, a style, and a mood. The sense of each key is defined by the order in which it is struck. This multiplicity of meaning is called polysemy and is the way human language works.

For example, in the sentence "They will play a tape of the play," no one would confuse the two uses of the word "play." Many of our words in English are polysemous and depend on their context for meaning.

Polysemy and redundancy are the foundation of Minspeak. The incorporation of polysemy into the design allows a small number of keys to have hundreds of referents. The amount of information carried by a letter is small; that borne by a word is considerably larger. The information in a visual image is enormous.

Hardware Configuration

Minspeak requires a keyboard coupled with a microprocessor. The EPROMs are used to store complete sentences without regard to individual words, phonemes, or letters. In addition, a commercially available speech synthesizer such as the Votrax Speech PAC with an SC-01 voice-synthesizer chip can be used. The output of the voice synthesizer is in turn coupled to a loudspeaker which generates audible synthetic speech. Because the preprogramming is done on the basis of semantic rules, Minspeak will be able to achieve a vocal quality unobtainable with text-to-speech methods. (See figure 1 for a diagram of that configuration.)

The keyboard design is illustrated in figure 2, with each circle representing an individual key. Each key has an illustration of a common object or an action. In most Minspeak embodiments the majority of the keys also have identifying sequential numbers, a letter that corresponds to the number, a portion of the human anatomy, and a proper name. The keyboard design shown in figure 2 was intended to be used by someone with a relatively high level of intellectual achievement. (See table 1 for a detailed description of the keys.) Simpler keyboards are designed for users with different intellectual levels.

For example, with this keyboard design, key #10 has an illustration of philosopher Bertrand Russell, famous for his paradox, "the set of all sets, not sets of themselves, etc." This key is used to change topics. A simpler board would use the same key for this purpose but would illustrate it with a frog that is jumping. (See figure 3 for examples of other keyboard images.)

The microprocessor is programmed so that hitting any one key twice designates that key's central image as the

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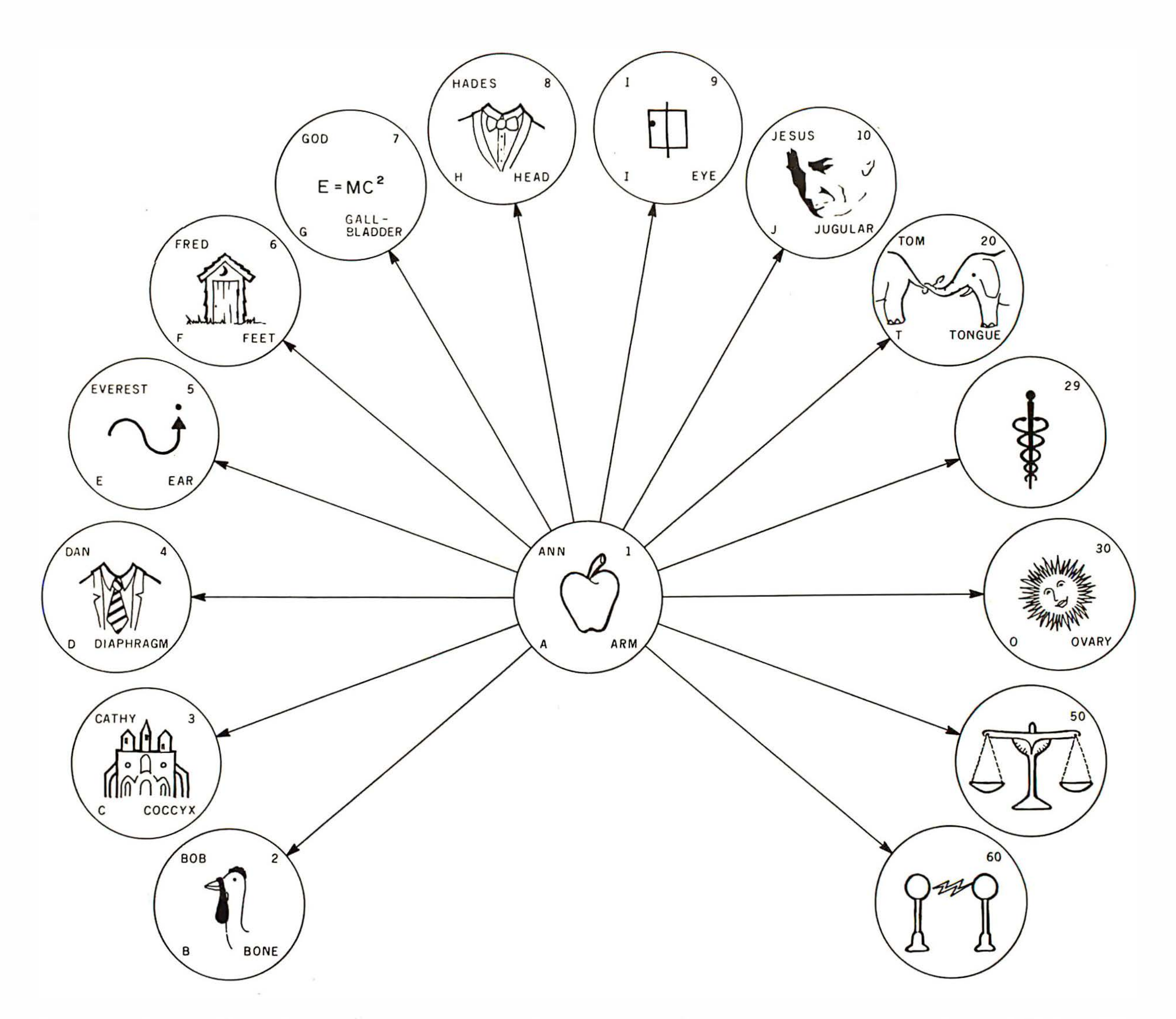


Figure 2: *The images on Minspeak keys represent neither letters nor words, but concepts. Because a picture is, indeed, worth a thousand words, the meanings of the symbols can change according to the order in which the keys are struck. Each image is rich in associations. In short and obvious combinations, they represent whole thoughts. When such combinations are actuated, sentences are spoken by the synthesizer. (See table 1 for a description of the information on the keys. See table 2 for examples of specific sequences.)*

Key #	Image	Theme	Letter	Anatomy	Person
1	apple	eating or food	A	arm	Ann
2	turkey	bad or danger	B	bone	Bob
3	cathedral	wheelchair	C	coccyx	Cathy
4	tie, shirt	dressing or clothing	D	diaphragm	Dan
5	directional arrow	transport or travel	E	ear	Everest
6	privy	ablutions, bathing, or water	F	feet	Fred
7	equation	philosophy or ideas	G	gall bladder	God
8	tuxedo	formalities, departures, or greetings	H	head	Hades
9	Chinese symbol, center	personal opinions or disclosures	I	eye	I
10	Bertrand Russell	logic or modality	J	jugular	Jesus
20	elephants	tag questions	K	tongue	Tom
29	caduceus	medical	—	—	—
30	sun	positive expression or happiness	O	ovary	—
50	scales	typing mode	—	—	—
60	electric current	electricity or control	—	—	—

Table 1: *Each key may have several functions depicted. The majority of the keys have a number, a letter, a portion of human anatomy, a name, and an illustration. The theme of the key is the topic that is selected when the key is hit twice. The information in this table corresponds to the keys pictured in figure 2.*

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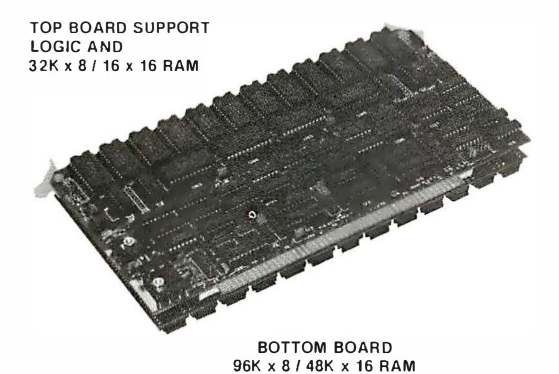
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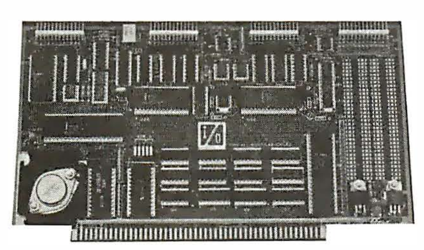


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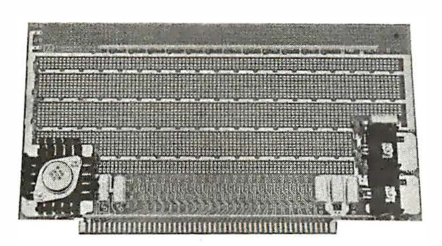
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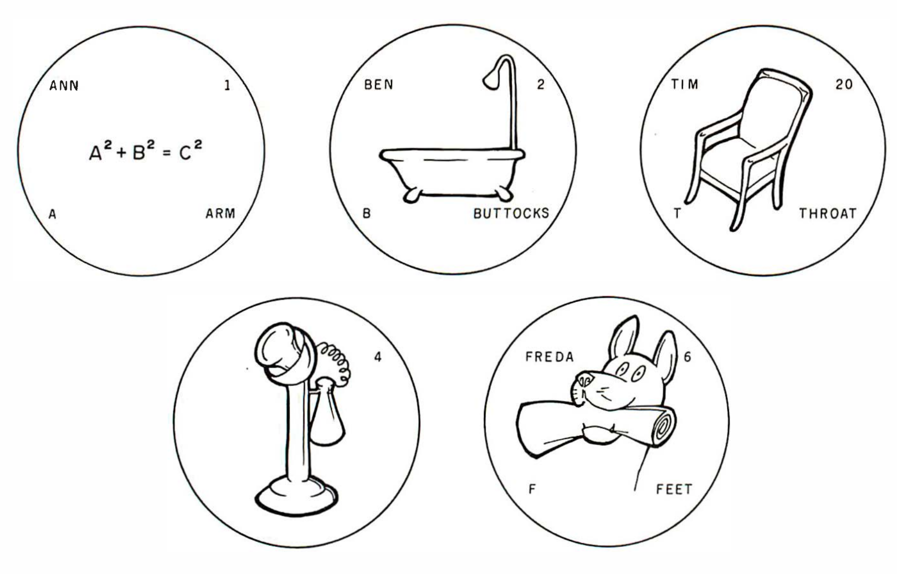


Figure 3: *Minspeak keyboards designed for people who can read have numbers and letters to aid in sequencing and lessen any unnecessary memorization. The letter generally stands for a word associated with the central concept behind the key. Key #1 prefaces statements dealing with numbers. The associated word is algebra. This key was designed for a 40-year-old man with cerebral palsy who is beginning college. Key #2 deals with cleaning and liquids. It's associated word is bath. Key #20 deals with transport and is from a keyboard for a person who does not like the traditional wheelchair symbol. The associated word is throne. Key #4 is from a keyboard designed for a Minspeak user who does not read. The associated idea is "call 4 help." Key #6 is for commands. The associated word is fetch. The names in the upper left area of the keys are of family members and friends.*

topic (see figure 4). All keys hit thereafter designate ideas associated with that topic. This continues until the user signifies a change of topic by hitting key #10.

For example, when the user hits key #1 twice, the topic of eating is established. When key #2 is hit, the sentence "Get that food out of my mouth!" is read from memory and spoken through the voice synthesizer and loudspeaker. If key #3 had been hit after the eating topic had been established, the sentence "The position of my chair is not right for eating" would have been generated. Using key #4 would have produced "Look out; the food is getting on my clothes."

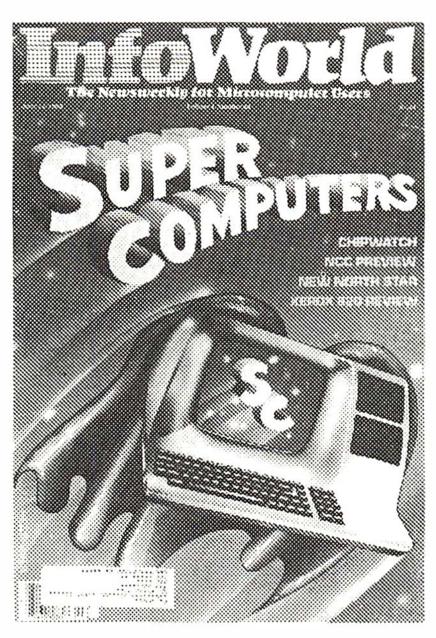
The programming also recognizes a single keystroke after the establishment of a topic as a request for a negative sentence or expression. This was done because negative sentences are often of an emergency nature and the user needs to be able to convey the message quickly and easily. A positive phrasing of each of the preceding

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The Influence of Language

Language has such a pervasive influence on perceptions and thought processes that so far we've been unable to devise a way to measure the depth or extent of that influence. To say an issue is "just semantic" is a contradiction. A person may as well say "just life or death." Americans of African descent are not nit-picking when they insist that "black" replace "colored." Nor are women being petty when they use "Ms." The way a person is described affects how he or she is treated.

People with physical disabilities can be isolated by the language used to describe them. I recently formed a small company and one of my two partners uses a communication aid because he has cerebral palsy. For me to call him or even think of him as "afflicted" would be bad for business. To call someone a "victim" of polio or to say a person is "suffering from multiple sclerosis" leaves a negative impression. Most people find it hard to deal with anyone they view as a "suffering victim." To say "He had polio" is easier and clearer.

"Confined to a wheelchair" is an especially unfortunate phrase. People are not "confined" by wheelchairs; they use them for mobility. Some people are tortured for years by unsuccessful attempts to enable them to walk. Wheelchairs can operate with grace and efficiency. It's harmful to perpetuate prejudices against them.

Adults with disabilities are often spoken of and hence thought of as children. I know a gray-haired professional with cerebral palsy whose wife was recently asked who the crippled boy with her was.

On the other hand, try not to let this list of "don'ts" make you feel anxious, because people with disabilities are often isolated by other people's fear of making a faux pas. Be natural. Most people with disabilities are skillful in dealing with all kinds of situations. It's the prejudices of the able-bodied community that are destructive.

When I am in a quandary about whether to use a certain word or not, I just ask myself, "Would I like my partner described that way?"

More information is available in a pamphlet, "4 Letter Words in the Dictionary of the Disabled," from United Cerebral Palsy, 66 East 34th St., New York, NY 10016.

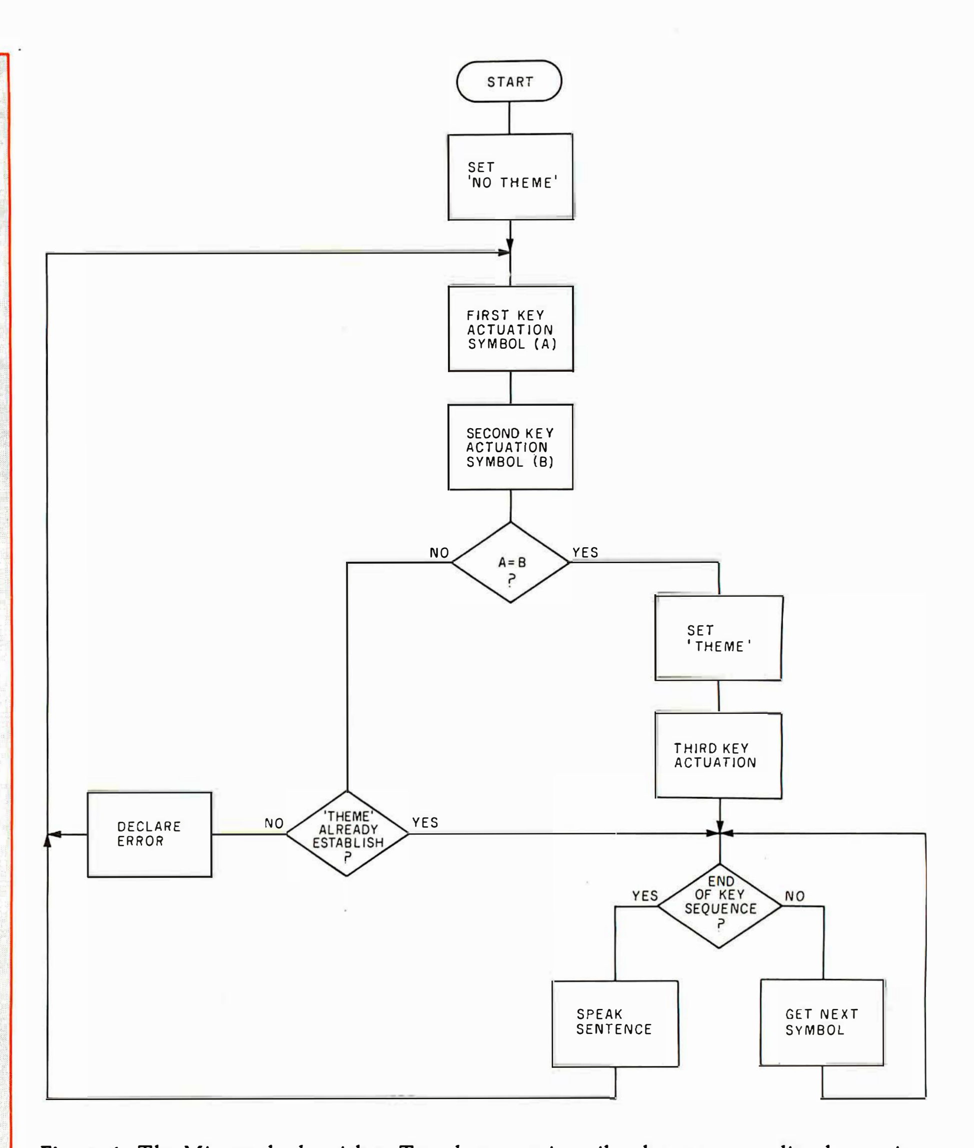


Figure 4: *The Minspeak algorithm. To select a topic strike the corresponding key twice. All sequences then deal with that topic until another topic is selected. Escapes, though not shown, are available for a variety of emergency situations.*

examples can be made by modifying the key sequence. The following sequence—key #1 twice (to set the topic), key #30 once (to denote a positive response), and then key #2 or key #4—would result in "It's okay; I'm not choking" or "It's all right if a little food gets on my clothes."

For a severely disabled person to say these sentences on a text-to-speech or phonemic system would require the user to select dozens of keys plus have the ability to read and spell very well. Minspeak requires no more than four key selections, and reading and spelling don't matter.

Many other variations and combinations of the keys are available to the user and will result in different sentences being output. For examples of other sequences, see table 2. For users with some linguistic sophistication, a series of keys can provide a method for altering existing sentences through insertions and deletions.

Other options include changing the person, number, tense, voice, and mood of verbs. Subjects and objects can be modified, eliminated, or reversed. A "fudge-factor" key introduces sequences to produce more than 100 sentences linguistically designed to correct or clarify enunciated sentences that inaccurately represent the user's thoughts. An example of one of these sentences could be "That's not what I meant." Style and context keys can easily alter the

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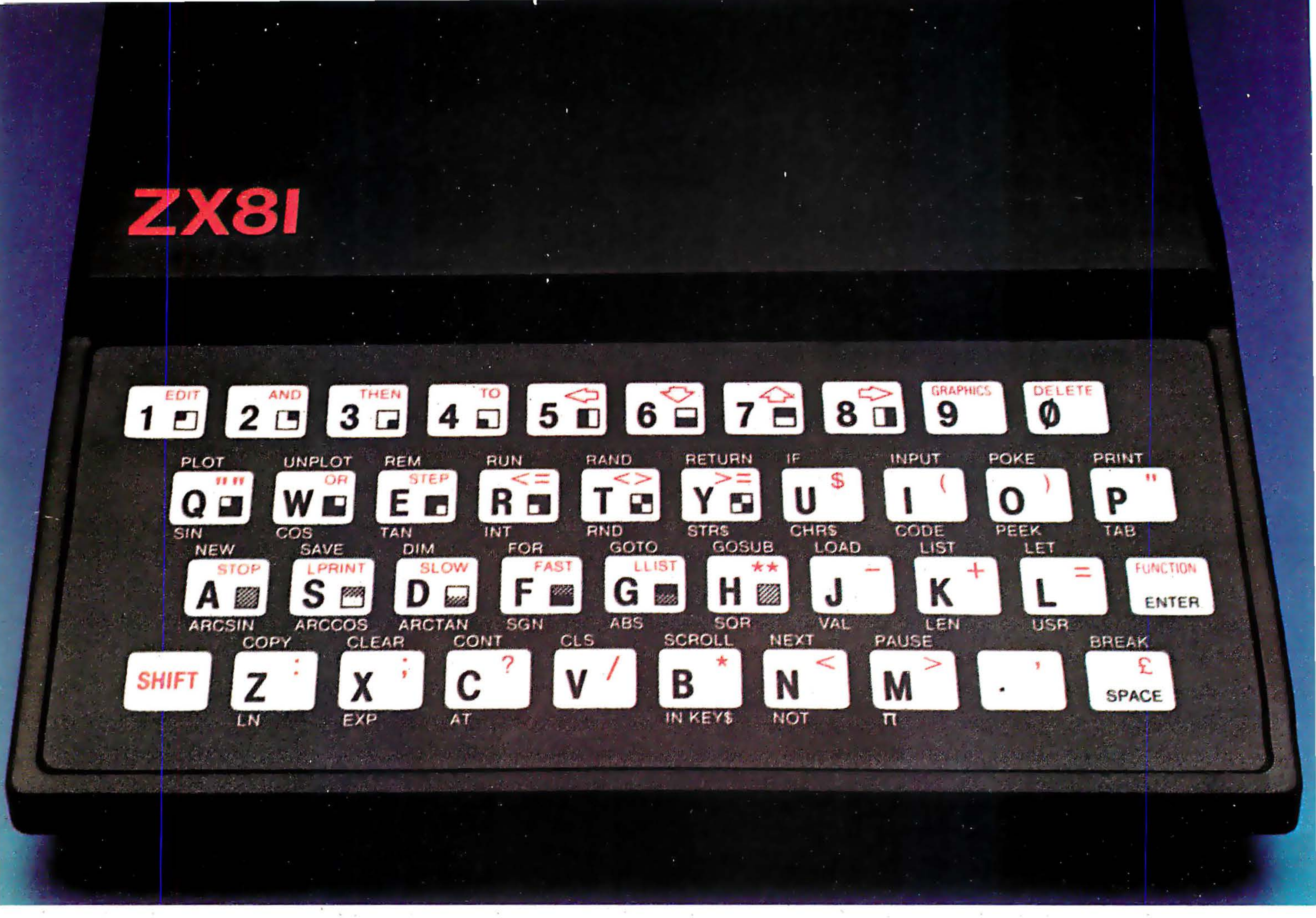
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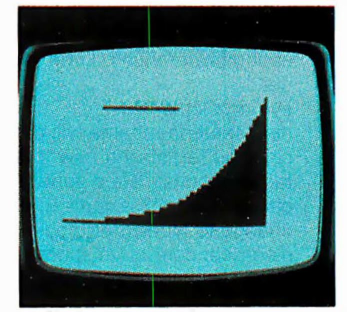
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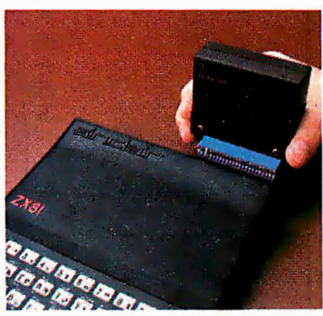
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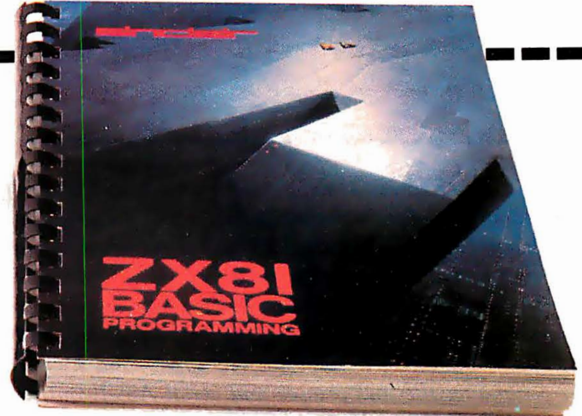
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Topic Key	Sequence Key	Possible Meaning
3	1	oil the chair
3	2	bad brakes
4	2	tie is choking; belt is tight
5	2	chair won't move
29	2	bone, joint pains
7	3	philosophy of religion
29	3	coccyx and seating problems
29	4	breathing, diaphragm problem
5	1	eating plans for a trip
60	6	no water in wheelchair battery
7	1	eating preferences; I'm a vegetarian.
29	8	head
29	9	eye problems
—	10	next sentence theme will differ
10	—	clear buffer; start a new topic
20	—	tag questions; "He's gone, isn't he?"
30	—	changes negative context to positive
50	—	change to typewriter mode
60	—	electrical control; telephone dialer, TV switches

Table 2: *To generate a sentence, the user must hit a key twice to set the topic, and then hit one or more keys to select a sentence pertaining to the topic. For example, if the user hits key #3 twice to set the topic and follows that by hitting key #1, a sentence pertaining to oiling the chair would be generated. The information in this table corresponds to the keys pictured in figure 2.*

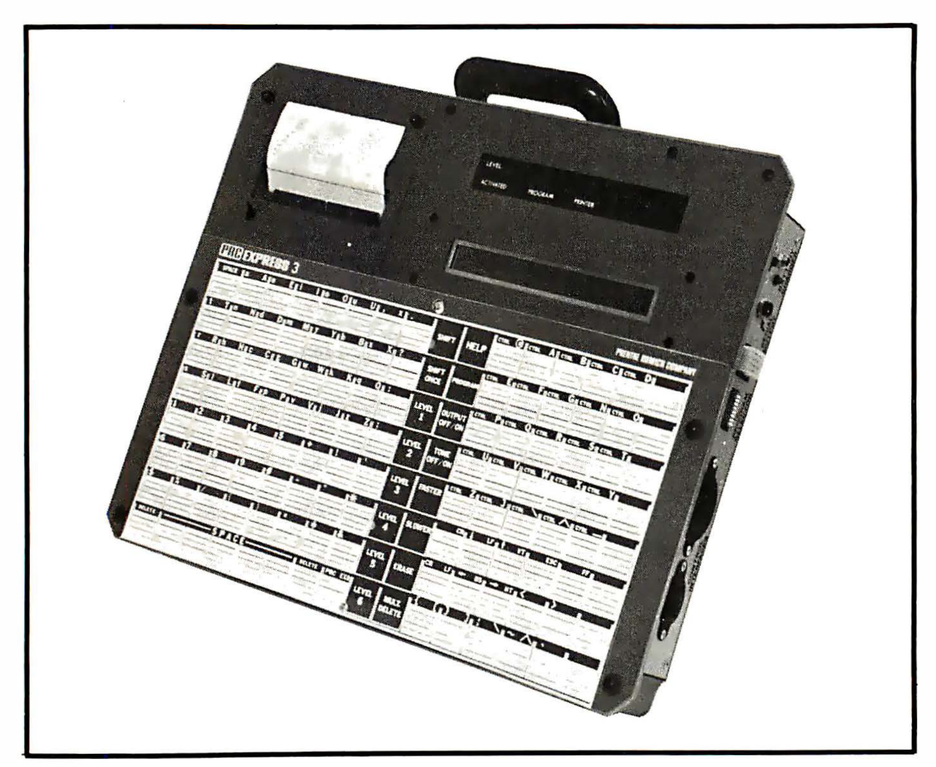


Photo 2: *The Express 3, developed by Prentke Romich Co., is a portable communication aid powered by internal rechargeable batteries and designed for mounting on a wheelchair. A special Express 3 is being prepared to implement the Minspeak concept. The system will use a combination of power-strobed EPROM and CMOS RAM. A Votrax Speech PAC with an SC-01 voice synthesizer marketed by Vodex will be coupled to the output of the microprocessor. It will retain other features of the original Express 3, including a 40-character upper- and lowercase liquid-crystal display with corresponding thermal printer and serial ASCII output for connection to other computers and environmental-control devices.*

vocabulary and social tone of the stored sentences.

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If communication-aid users could access any of these sentences with a few physical responses, their expressive difficulties would be on the road to resolution. Actual field work has shown that the number of sentences whose sequences can be easily remembered and used is unexpectedly high, perhaps approaching the thousands for a large percentage of potential users.

Minspeak is currently under development at the Prentke Romich Co. in Shreve, Ohio. PRC is working on the development of expressive communication aids for the severely physically disabled. A demonstration prototype of Minspeak will be available from the company later this year. Until now, the effectiveness of communication aids has caused agencies to question their definition as a prosthesis and this has limited the amount of outside funding available. Because of the advances represented by Minspeak, a coordinated multistate legal campaign has been launched to persuade private and public health care funding agencies to make funding available for purchase of this device.

People who hear and cannot speak have an enormous potential for contributing to society through their insights into human communication. It is my sincerest hope that Minspeak will give them access to modern technology that will enable them to make this contribution in an easier and more productive way. ■

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FDA Regulation of Computerized Medical Devices

What designers of medically related hardware and software should know.

Joseph Jorgens III
Carl W. Bruch
Frank Houston
Bureau of Medical Devices
Food and Drug Administration
8757 Georgia Ave.
Silver Spring, MD 20910

Most people know that when a device is used for medical purposes, it falls under the jurisdiction of the Food and Drug Administration (FDA) of the U.S. Public Health Service. Now, with the advent of the microprocessor, many existing medical devices have become computerized, and new medical equipment is being designed with microprocessors. Consequently, many hardware and software producers may be required by law to notify the FDA of their medical devices. And those designing such devices or producing software for medical purposes should be aware of the regulations and the manufacturing controls that must be followed in order to comply with the Medical Device Amendments of 1976.

The Law

The Medical Device Amendments of 1976 to the Federal Food, Drug, and Cosmetic Act gave the FDA the responsibility and authority to assure that medical devices are safe and effective.

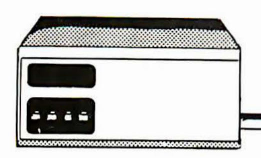
As defined by the amendments, a medical device is an "instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including any component, part or accessory, which is intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man or other animals, . . . which does not achieve any of its principal intended purposes through chemical action within or on the body."

Many hardware and software producers may be required by law to notify the FDA of their medical devices.

Levels of Control

The amendments provide three levels of controls to assure the safety and effectiveness of medical devices. They are Class I, devices requiring general controls; Class II, those requiring specific performance standards; and Class III, those requiring premarket approval. Medical devices such as bedpans and surgical instruments for which general controls are adequate to ensure safety and effectiveness fall into the Class I category. General controls prohibit adulteration and misbranding of a medical device. Under the amendments, adulteration may include failure to follow Good Manufacturing Practice Regulations, comply with an FDA standard for a device, or submit a premarket approval application. Misbranding may include failure to register production facilities, list a device, or properly label the medical device, e.g., by not providing adequate directions for use. Labeling is not confined to the label on the device itself but may include any literature accompanying the device, operating or service manuals, and advertisements for the device.

Class II products require a specific performance standard, as well as the general controls, in order to provide reasonable assurances of safety and effectiveness. For example, devices such as those that make measure-



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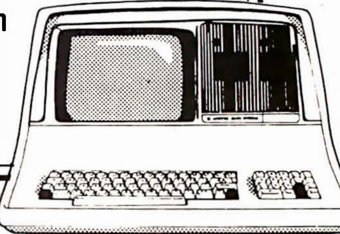
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ments or amplify physiological signals fall into this category. The amendments gave the FDA authority to establish mandatory performance standards for these products. Equipment such as electrocardiographs, blood-pressure meters, and medical thermometers are in Class II. Class II also contains some devices whose use entails some risk for the patient, such as defibrillators and electrical nerve stimulators.

A Class III device is one that may pose a significant risk to health from its use and for which there is insufficient information available to develop a performance standard. This would be the case, for instance, in new measurement techniques, new treatments, or artificial organs. Many implantable devices are in this class. In order to bring a Class III medical device to market, a manufacturer must demonstrate to the FDA that the device is safe and effective. The results from animal studies, clinical trials, and in vitro studies for the medical device are submitted in a premarket approval application to the FDA for review.

In the FDA, the Bureau of Medical Devices has the primary responsibility for regulating medical devices as defined above. Several working groups within the Bureau are charged with carrying out different provisions of the act. Medical device manufacturers usually interact with the Office of Compliance, the Office of Device Evaluation, or one of the FDA's field offices.

The Office of Compliance is responsible for assuring good manufacturing practices as well as administering recalls and examining any violations of the act. Legal actions such as seizures, injunctions, and prosecutions are also part of its activities. Manufacturers who bring a new device to market generally deal with the Office of Device Evaluation, which is divided into seven medical specialty groups. (For this discussion, the term *manufacturers* will include producers of both software and hardware.) Advisory panels composed of experts from outside the FDA assist each division in its specialty area.

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Device evaluation is concerned with new products that will be placed in commercial distribution. Products that are new, those that have been "significantly modified," and "me-too" products (copies of devices already on the market) from a new manufacturer require a premarket notification from the manufacturer 90 days prior to marketing the device. The premarket notification is called a 510(k) submission since it is required by regulation 510(k) of the Federal Food, Drug, and Cosmetic Act. During this 90-day period, the appropriate Device Evaluation division reviews the premarket notification and determines whether or not the product is substantially equivalent to a device that was in commercial distribution before May 28, 1976, the date on which the Medical Device Amendments became law. If the product is substantially equivalent, it may be commercially distributed. A product that is not substantially equivalent to a pre-amendments device, and which has not been reclassified, is placed in Class III and requires a premarket-approval application that is reviewed by FDA staff as well as by the advisory panel to determine whether the safety and effectiveness of the device have been demonstrated. If they have, the product will be allowed into commercial distribution.

Computers and Medical Devices

With the advent of microprocessors came two developments for medical devices. First, microprocessors began to replace discrete components, and second, totally new devices became possible. The first development augments the reliability of medical devices and also allows great flexibility without the necessity for major hardware design changes. The second development arises from the ability to implement very complex logical decision schemes with a relatively inexpensive piece of hardware. In addition, the proliferation of personal computers and associated software allows individuals to produce small, very intelligent medical devices and medical software.

Microprocessors that are components of medical devices or of large computing systems that interface with medical instruments are normally considered medical devices. Software that is written for such systems may be classified as a medical device. By identifying the purpose of the system and the function of the software within the system, you can determine if your hardware and software are medical devices.

Hardware

Products that apply the latest technology (often using microprocessors) to perform the functions of discrete component designs will not be regulated in a manner significantly different from their predecessors if the use of the microprocessor does not change the medical nature of the product. Consider, for instance, the electrocardiogram monitor, which has evolved from electron tubes, to transistors, to integrated circuits, and finally to microprocessors. The hardware and software of the latest generation of monitors are regulated to the same extent as the tube model was, as long as the two generations of

monitors are substantially equivalent.

If a microprocessor in the monitor automates a process, say, by automatically infusing a drug when a certain electrocardiographic pattern is present, then the medical nature of the device may be considered changed. The monitor may be no longer primarily a provider of data; it might now be a maker of medical decisions, and if this device were the first of its kind, it might be regulated as a new (Class III) device.

Software

The subject of software is a bit more complex. Software gives medical devices flexibility and can be portable from one computer system to another. For the sake of simplification, consider four software categories:

1. software that is permanently installed in a specific medical device not intended to be altered by the user and required for the device to function
2. software that may be temporarily installed in a specific medical device with the capacity to alter the function or performance of the device
3. software designed for use on a single, general-purpose computer (that is, a computer not specifically dedicated to one particular device)
4. software designed for use on multiple, general-purpose computers

Category 1. In this case, the software is really a fixed component of the instrument. If the instrument is a medical device, so is the software. The level of control will be governed by the device function or purpose of the instrument.

Category 2. This software is a replaceable component, somewhat like a phonograph record. It may change the performance of the instrument and make it function as a different medical device. Again, if the instrument operates as a medical device, the software enabling such operations will also be considered a medical device.

Category 3. Suppose a software package is developed for one minicomputer system that might accept EKGs from a 10-bed intensive care unit, analyze the electrocardiograms, and make a diagnosis of the patients' heart conditions. This would fall into Category 3. Because it accepts data from a patient and makes a diagnosis, it falls within the definition of a device and is subject to regulation.

Category 4. Category 4 would apply to a package developed in one of the high-level languages such as FORTRAN, BASIC, or Pascal. Categories 3 and 4 contain gray areas with respect to the medical-device definitions. If someone takes several medical textbooks, develops a decision process leading to a diagnosis,

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IBM—PC DOS, USCD, etc.

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and automates the process, is the resulting program a medical device? No definite decision has yet been made. Even if this automated process is considered a medical device, how should the Bureau of Medical Devices analyze the 510(k) submissions? Perhaps the appropriate method would be to ask whether the algorithm that is used is substantially equivalent to the algorithm that was employed manually. If the algorithm were the same, the computerized version of that process would be determined to be substantially equivalent to the manual version and would not be covered by Class III regulations.

As you may imagine, the issue of software as a medical device is complex and still in a state of flux. Perhaps some examples of software products that have already been examined by the Bureau of Medical Devices will provide some clarification.

One product that was reviewed by the Bureau of Medical Devices was a microprocessor-based monitor that measured several patient parameters such as blood pressure and heart rate, manipulated those measured parameters, and displayed the measurements in both a real-time fashion and in a trend plot. The product, including its software, was considered to be a medical device.

Another product used hardware, leased or sold to a hospital, that measured pulmonary parameters. The raw data was sent to a computer by way of phone lines. The computer manipulated the raw data and returned a display of the patient's pulmonary functions to the hospital. Because the data manipulator and its software made claims for medical purposes and required the leased or purchased front-end hardware system, it was considered a medical device rather than a service and fell under the Bureau of Medical Devices regulations.

A new pulmonary-function analyzer uses an Apple II microcomputer to measure a patient's breathing with an electronic flowmeter, analyze the information, and print out a graph of the patient's pulmonary function. This is considered a new medical device, but because it merely does the same analyses that were once done by hand, it was determined to be substantially equivalent to a preamendments device and was not placed in Class III.

Another firm uses a computer to analyze X rays and patient information received from hospitals to determine the patient's future growth statistics. Several X rays and a history of the patient are mailed to the company where the future growth parameters are predicted by way of a programmed algorithm. The Bureau of Medical Devices considered the firm a *service* provider, and although the programmed algorithm is a medical device, it is not subject to active regulation except for the regulations regarding misbranding and adulteration.

Products that fall into this limited level of regulation must meet the following criteria:

1. The product must be a computer software package essentially based on data-analysis methods appearing in the literature.
2. Only services provided by the software can be sold. The software itself can't be sold or leased to users or other service providers.
3. The data used as input by the software must be generated by a commercially available device.

In this instance, if the firm were to market the software package that guides the calculations, such a package would be an actively regulated medical device.

Conclusion

This article has been a limited discussion of FDA regulation of computerized medical devices and medical software. Many details have been omitted. Designers of medical software and hardware should obtain additional information by contacting the Office of Small Manufacturers Assistance, Room 1431, 8757 Georgia Ave., Silver Spring, MD 20910 (301) 427-7184. ■

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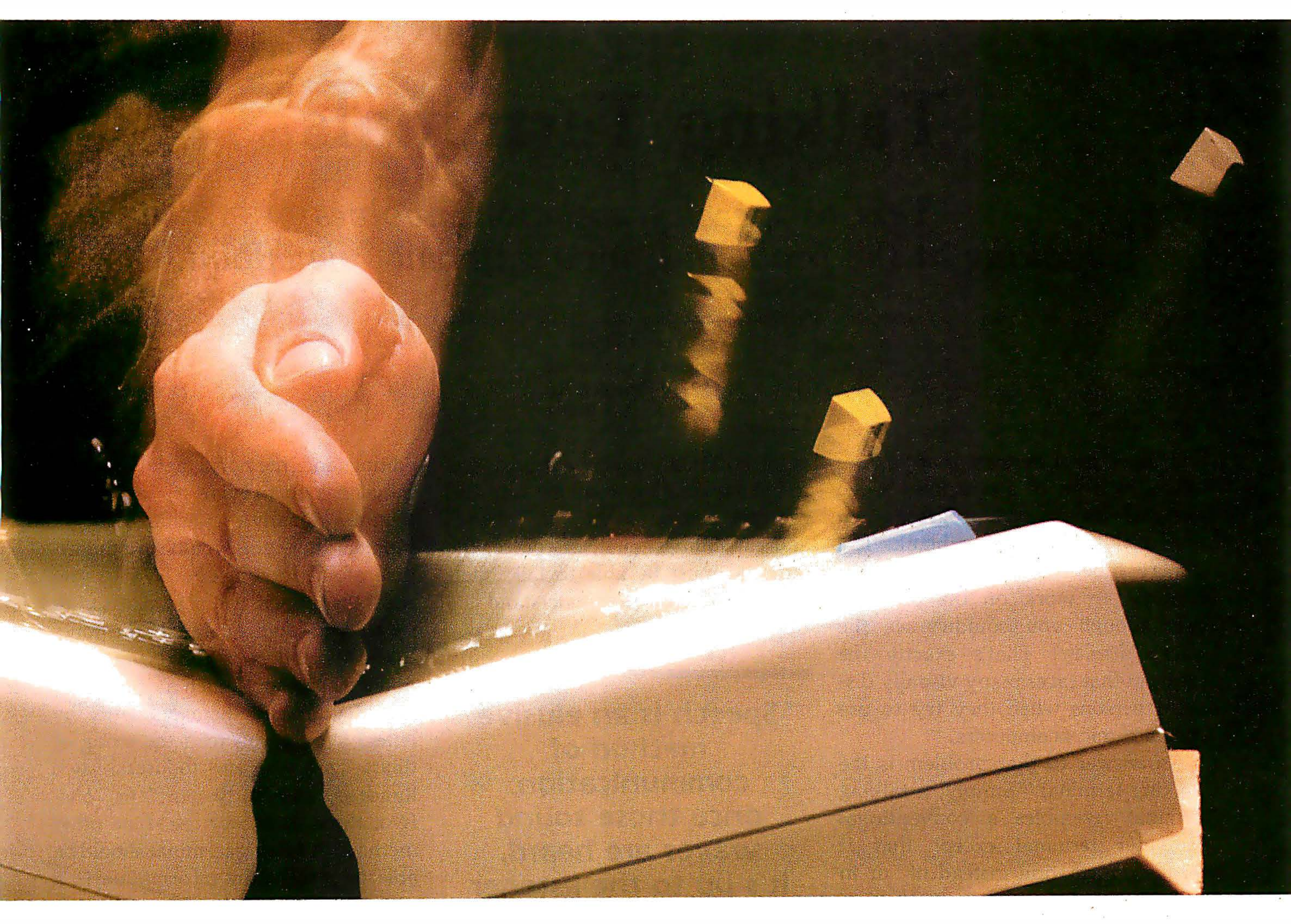
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Talking Terminals

Text-to-speech translation involves looking at the problem from a different "viewpoint."

David Stoffel
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Imagine for a moment that you are sitting in front of a computer video terminal working on a program when suddenly the screen goes blank. The display tube has failed. Could you continue to work on the program even though you couldn't see the screen display? That's exactly the problem that faces many visually disabled persons when they try to use standard microcomputers.

An answer to that problem is the "talking terminal." Simply, a talking terminal resembles a conventional computer terminal except that it speaks information instead of, or in addition to, displaying that information visually. This article aims to offer an understanding of the human factors involved in selecting a talking terminal and to compare current talking-terminal products.

About the Author

David Stoffel has participated in the research and development of voice-response technology for six years. He has built his own talking terminal as a research tool and for his personal and professional use.

In addition to conventional terminal capabilities, a talking terminal requires several additional features and capabilities. First, of course, the terminal must be able to talk intelligibly for you to understand its speech. So, we want to assess the intelligibility and acceptability of the product's speech. Second, speech is an elusive method of communication; once those sound waves are heard, it's up to the listener to remember what was said. So, just as many video-display terminals provide local editing and memory, a talking terminal has to provide a "say again" feature. Finally, consider, for a moment, how you would read this article aloud to someone. Would you read the punctuation as pauses, or would you say the names of the punctuation symbols? Would you pronounce acronyms, such as ASCII, or would you spell them out letter by letter? Would you read the string of digits 1234 as "one thousand, two hundred, and thirty-four," or "one, two, three, four," or use some other method? A talking terminal should be able to present the information in a variety of ways, suited to your needs and preferences.

Speech is an elusive method of communication; once those sound waves are heard, it's up to the listener to remember what was said.

Today's commercially available talking-terminal products (see table 1) represent two different design strategies. The speech-related features and capabilities have either been built into an existing conventional computer terminal, as with the Total Talk and the FSST-3, or are in a self-contained accessory module connected in series on the communication line between the computer and the terminal, as with the VERT. These two design


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Product:	VERT (Verbal Emulation in Real Time) Self-contained speech unit connected in RS-232C communication line between computer and any terminal.
Price:	$5900 (with educational discount $4990)
Manufacturer:	Automated Functions Inc. Suite 813 4545 Connecticut Ave. NW Washington, DC 20008 (202) 362-6292
Product:	Total Talk (other models are available) Hewlett-Packard HP-2621 terminal with added speech circuitry.
Price:	$4990
Manufacturer:	Maryland Computer Services Inc. 2010 Rock Spring Rd. Forrest Hill, MD 21050 (301) 838-8888
Product:	FSST-3 (Free-Scan Speech Terminal) Zenith Z-19 terminal with added speech circuitry.
Price:	$4495
Manufacturer:	Triformation Systems Inc. 3132 Southeast Jay St. Stuart, FL 33494 (305) 283-4817

Table 1: *Manufacturers of talking terminals.*

strategies have significant ramifications in two of the three areas of comparison: speech review and speech-parameter control.

Translation Algorithms

An exhaustive comparison of the intelligibility and acceptability of the speech output—measures of listener comprehension and preference—requires rigorous performance measures. Such scientific evaluation is beyond my resources. Nevertheless, I can offer some useful observations on the different text-to-speech algorithms used in these talking terminals.

Though some manufacturers do not acknowledge the ancestry of the text-to-speech algorithms they use, it is reasonably safe to infer that both the VERT and Total Talk use the McIlroy (Bell Laboratories) algorithm, as enhanced by NIH (National Institutes of Health), and that the FSST-3 uses the NRL (Naval Research Laboratory) algorithm. The McIlroy enhanced algorithm uses about 1000 rules, and the NRL uses about 600 in performing the letter-to-phoneme or word-to-phoneme translation. (A phoneme is the smallest sound unit of speech. When we speak, we string phonemes together to produce words.)

Both algorithms are quite adequate, with translation accuracy, linguistically speaking, of about 90 percent. In my experience, I find that the McIlroy algorithm handles difficult words correctly more often than the NRL. Neither of them makes any particularly egregious errors in the text-to-speech translation.

Choosing Synthesizers

The only viable synthesizers to date are those that use phoneme synthesis, rather than synthesis by analysis (speech encoding), because the synthesizer must be able to speak an unrestricted vocabulary. The speech-encoding synthesizers, such as Texas Instruments' TMS5221 LPC (linear-predictive coding) synthesizer or National Semiconductor's Digitalker, are still limited to fixed, prerecorded vocabularies. Both the VERT and the Total Talk use the Votrax VSB single-board speech synthesizer; while the FSST-3 uses the older Votrax VSA.

Both Votrax synthesizers are capable of independent variation in speech rate and pitch, under either manual or program control. The VERT takes advantage of the programmable-speech-rate control to enhance the pronunciation duration of very short and very long words, while also providing you with

manual speech-rate and pitch controls. The Total Talk and the FSST-3 offer you manual speech-rate and pitch controls.

The Votrax VSA and VSB synthesizers seem quite similar with respect to their phoneme production, but the FSST-3, which uses the VSA, definitely sounds inferior; whether this is an artifact of the VSA synthesizer or poor audio amplification, I don't know.

You may wonder why none of these products uses the new Votrax SC-01A integrated circuit, which is less expensive. The single-quantity cost of the VSB is about $800, while the SC-01A is $70. But there are two major reasons why the SC-01A is not used. The speech-rate and pitch controls are both dependent on the same clock signal or timing circuit, affecting the ease with which intelligible speech may be produced. Also some people are concerned about the acceptability of the SC-01A's sound quality. Only scientific performance measures can determine which Votrax synthesizer is ultimately more intelligible. (For a description of an application using the Votrax SC-01A speech-synthesizer chip see Steve Ciarcia's article on page 64 in this issue.)

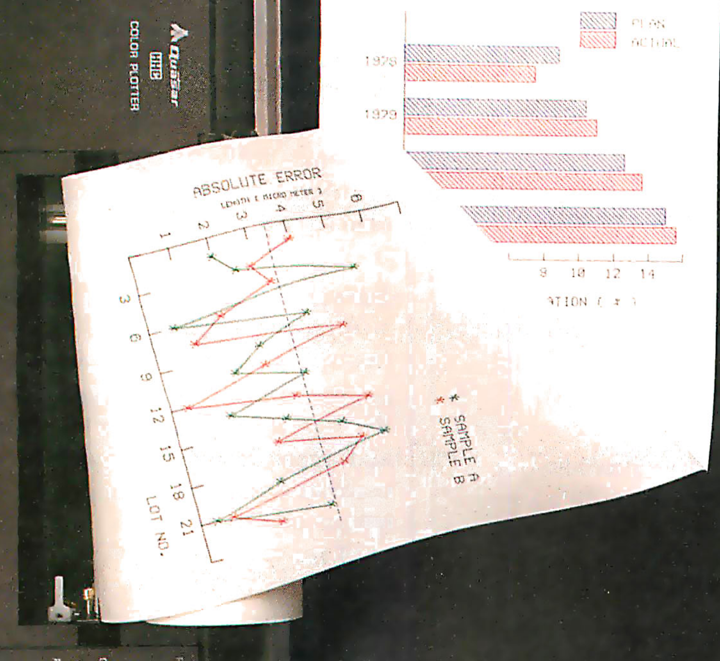
Speech-Review Capabilities

Imagine that a talking terminal is reading this article to you. Suddenly, you wonder at what you just heard—either a terrible pronunciation of a proper name (like "Ciarcia" perhaps) or maybe just a word that you don't recognize. You would like to stop the speech, perform some review functions to repeat the last few lines or words, or spell the word in question, and then continue the speech just where you stopped it.

Stopping the speech output of a talking terminal requires that the stream of characters coming from the host computer to the terminal be halted. (Some remote computers make this very difficult.) Only the VERT attempts (when the feature is enabled) to tell the host computer not to send any more text when reviewing. The Total Talk loses data after receiving 120 characters of yet-untranslated text from the host computer. The FSST-3 loses data after accumulating 1920 characters of yet-untranslated text.

All three products allow you to review the text saved in memory. The VERT saves the most recent 12,000 characters, the Total Talk saves two screens (48 lines of 80 characters each) in the HP-2621's display memory, and FSST-3 saves from one to three screens (depending upon the amout of memory installed) in the Zenith Z-19's display memory. All three products can repeat the text in its entirety or by character, word, or line. In addition, the VERT can repeat text by phrase, sentence, or paragraph.

The Total Talk and the FSST-3 perform their review functions as a result of using the standard cursor-movement and screen-print functions of the HP-2621 and Z-19 terminals. The VERT responds with its review function to an ASCII (American Standard Code for Information Interchange) escape-code sequence from any data-terminal equipment.



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The integration of speech capability with an existing, popular terminal design—the case for both the Total Talk and the FSST-3—has positive and negative consequences. Such integration negates the need to acquire a computer terminal separately when you shop for a talking terminal. On the other hand, building the speech circuitry into terminals has resulted in a performance characteristic especially annoying to programmers: both the FSST-3 and the Total Talk (Z-19 and HP-2621 terminals, respectively) never speak cursor, character-attribute, or print-function codes.

Anyone who buys a VERT must also acquire a standard computer terminal. This terminal is connected to one of the VERT's two ports, while the computer (or modem) is connected to the other. The VERT transmits all characters received from the host computer to the terminal, while translating and speaking if appropriate. The VERT can also transmit all characters received from the terminal to the host computer, though usually some are trapped as the VERT function codes. This black-box filter-like approach to the problem of providing a talking terminal is modular and well formed.

Speech Parameter Control

A talking terminal should give you the option of setting speech-control parameters. It should either decide the most appropriate way to translate and speak segments of text where machine-based decisions are competent or provide you with the capability of manually setting those decision parameters which cannot be successfully handled by a machine. A program can decide whether to pronounce or spell IBM, NIH, or ASCII.

The VERT uses truth tables for prefixed and suffixed letter pairs to determine whether to spell or pronounce alphabetic tokens. It is rather more difficult for a program to decide whether to say 370 as "three seven zero," "three hundred seventy," or "three seventy." If the text is referring to an IBM 370 mainframe computer, the choice will be obvious to you. But

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Text-to-Speech Translation

Several independent efforts have resulted in various grapheme-to-phoneme translation systems for speech synthesis. Graphemes are letters or other characters, and phonemes are the sounds of speech. There are two approaches to the problem of translating written language (orthography) to its spoken (phonetic) form. All current efforts to create artificial speech use either one or both of these approaches.

The first approach searches a dictionary of words and/or word fragments (morphemes) for corresponding phonetic representations. Such dictionaries that are expected to satisfy a wide variety of contexts must be quite large. The software responsible for searching a dictionary must be able to account for various forms of a given entry. When dictionaries of morphemes are used, the software must be capable of separating the words to be translated into their constituent morphemes.

The second approach uses grapheme-to-phoneme translation rules. Such rules attempt to describe a correspondence between the orthographic and phonetic forms of the language. Some efforts have resulted in a combination of these two methods of translation, resorting to the second when the first fails to satisfy a translation request.

Unrestricted Text

In order to remove all restrictions on the content of the text being translated, the translation system must be able to distinguish among English words, acronyms, mnemonics, abbreviations, etc. The input stream of text to be translated is parsed into tokens that contain characters of the same type.

Tokens may be divided into types alphabetic, punctuation, numeric, or symbolic. A token is complete when a character in the input stream of another token type is encountered. The type of a token determines the classification of rules used in translating the token. The selection of the rule set is dependent on the token type. There are currently rule sets for English, numerals, punctuation, and spelling. Spelling is the English pronunciation of a single character's name. You must also consider that alphabetic characters do not always represent an English word.

Frequency tables representing the occurrence of letter pairs (digrams) or triplets (trigrams) offer significant help in deciding whether a group of characters represents an English word, an acronym, or a mnemonic. The frequency tables currently in use were derived from a lexicon of about a quarter of a million words. The digram-frequency table is reduced to a binary table that represents the occurrence or nonoccurrence of letter pairs in the lexicon. The use of digram or trigram tables could be expanded to the detection of specific subsets of English vocabulary. One case where this is useful: frequency tables derived from a common-usage dictionary and a lexicon of medical terms are significantly different.

Rule-Directed Translation

Orthographic representations of text are translated to phonetic representations by means of a production system. The rules used in the English-to-phoneme translation match context-sensitive patterns to the word or word token. The rules are of the form:

left-context [current-token]
right-context = phonemes

The current-token is the character(s) that is currently being translated by a rule. The left-context and the right-context are the text in which the current-token must be matched. These left- and right-contexts may contain special symbols that define arbitrary patterns of characters. The current-token may not contain these special symbols and must match, character for character, the token of the word being translated. The right-hand part of a rule gives the phonetic symbols representing the current-token. English phoneme rules are classified in subgroups of alphabetic, numeric, punctuation, and spelling rules. The phonetic replacements selected by the successful matching of rules are used to drive a speech-synthesizing device.

a translation program has no way of "knowing" the correct pronunciation of a number or word on the basis of the context in which it was used. The Total Talk and the FSST-3 simply speak numbers digit by digit. The VERT does the same or says numbers as whole words depending on your parameter setting.

Ironically, it's often desirable to make your talking terminal remain silent, while continuing to display and save text. The reasons are many, varied, and a matter of preference, but the capability is important. Total Talk will remain silent when you depress its Silence key. The VERT can be made to remain silent until a new line, speech command, or predefined text pattern is received. The FSST-3 can start or stop speaking on command.

No matter what the accuracy and proficiency of a text-to-speech translation system, there will always be words or symbols that you would like to have spoken your own way. For example, it is becoming popular in academic computer-science circles to use the word "bang" or "shriek" for the exclamation-point character (!). I am sticking with the conservative "exclamation," even though the newcomers are shorter and can be spoken more quickly. The VERT offers you the power to define, in English, your own translation preferences. You simply define a rule that says ! = "bang," or whatever.

On the Horizon

We may see the cost of talking terminals either decrease as new speech synthesizers are used, or increase as speech capabilities are integrated with personal computers. Whatever the result, the cost of a talking terminal will remain a serious problem for visually disabled persons. Talking-terminal manufacturers should expand the market for their products—not limit it to the visually disabled. Increased sales will lower costs and benefit everyone in the long run.

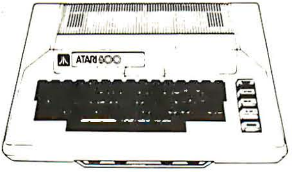
One perplexing problem remains. The rapid advance of video-display technology has promoted the ever-increasing use of video-dependent software. Users of talking terminals will require programmed solutions for describing essentially visual information. Unfortunately, information science is still far from providing accurate verbal descriptions of two-dimensional space, thus, for instance, making it impractical to run a screen-oriented program like Wordstar solely from spoken output.

Though the sound quality of available phoneme synthesizers is definitely far from human-sounding, I've found that visually impaired persons find it intelligible and acceptable with use. I believe that computers with natural-sounding speech and more sophisticated algorithms for translation will be achieved in this decade. ■

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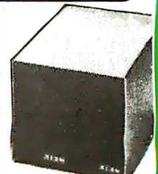


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The Cognivox VIO-1003

Voice recognition and output for the Apple II

Dr. William Murray
Computer Science Department
Broome Community College
Binghamton, NY 13902

The Cognivox VIO-1003, manufactured by Voicetek of Goleta, California, is a speech-recognition and voice-output peripheral for the Apple II computer. It is difficult to believe that for a modest $295 for hardware and software, you can actually carry on a conversation with your computer.

The Cognivox can be "trained" to recognize a set of up to 32 words or short phrases (e.g., one, two, alpha, syntax error, etc.) This allows you maximum flexibility because the Cognivox can be trained with a game, business, or scientific vocabulary. As a matter of fact, you can save several sets of vocabularies on a disk. During a training session you enter the vocabulary into the computer by repeating each entry three times into the Cognivox microphone and typing the entry once. This trains the machine to recognize *your* voice. Voicetek cautions that other people's pronunciations of the same words may or may not be recognized.

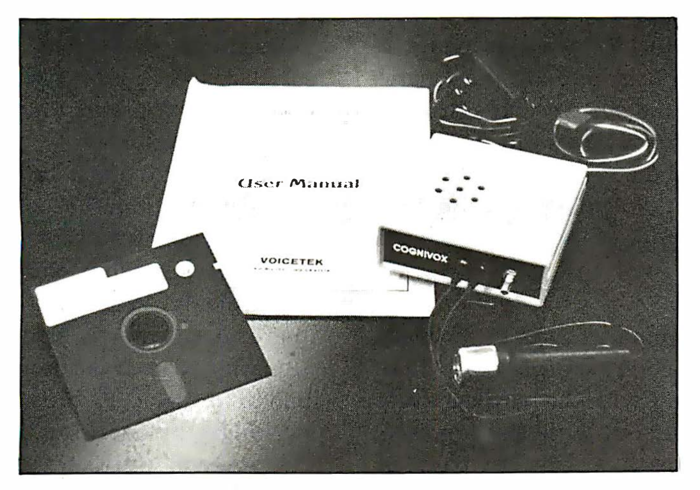


Photo 1: *The Cognivox VIO-1003 Voice Recognition and Voice Output System.*

The Cognivox, working within the frequency range of 100 to 3200 Hz (hertz), compresses essential speech information for one entry into a 48-bit pattern. This pattern is saved during the training session and will be used as a "mask," or model, for future comparisons. The system uses only 4K bytes of storage for the program and tables, and Voicetek claims up to a 98-percent word-recognition rate.

The voice-output vocabulary is entered in much the same way as the speech-recognition vocabulary. During a training session your words are digitized and stored in memory for future use. If you want your program to have voice output, the word or phrase is assembled and "spoken" through the built-in amplifier and speaker. The voice output sounds just like you, the trainer. Because the speech-recognition and voice-output vocabularies are independent of each other, a wide range of responses is possible.

It should be noted here that the Cognivox is not a speech synthesizer; it is a speech digitizer. The voice output is strictly limited to the words or phrases that you enter. However, because you can use multiple vocabularies, this is not a serious limiting factor.

Steve Ciarcia's article "Use Voiceprints to Analyze Speech" (March 1982 BYTE, page 50) covers the techniques used to record voice prints. Steve points out that the quality of the speech-recognition system depends on what he calls the "templates" of the spoken words. The template or mask quality in turn depends on how much storage is available. His device, which produces voice patterns on an oscilloscope, uses bandpass filters starting at 31 Hz and covers an 8-octave range up to 4000 Hz. The results presented in the article show that most speech falls between 1000 and 4000 Hz, which is just about the range of the Cognivox.

At a Glance

Name
The Cognivox VIO-1003

Manufacturer
Voicetek
POB 388
Goleta, CA 93116
(805) 685-1854

Price
$295

Hardware
Includes the Cognivox VIO-1003 (housed in a 5- by 6- by 1¼-inch plastic case), microphone, and power supply; frequency response 100 to 3200 Hz; audio output 150 mW; power consumption 150 mW during recognition and 450 mW maximum during voice output; power supply 9 V DC, 300 mA (unregulated, wall-transformer type); microphone jacks provided on front panel, remote amplifier jack provided on back panel

Software
The control program VOX4 and demonstration programs VDUMP, VTRAP, VOTH, and TONES, all on a 5¼-inch floppy disk

Capabilities
Recognizes isolated speech; digitizes up to 32 words or short phrases per vocabulary set; allows separate recognition and speech vocabularies; accepts words or phrases up to three seconds each in spoken length; typical recognition accuracy of 98 percent for the voice it is trained to accept

Hardware Required
Apple II with 32K or 48K bytes of memory, one disk drive, and DOS 3.3

Documentation
26-page manual

Warranty
120 days repair or replacement

Audience
Those seeking to communicate by voice with their computers; potential uses include security functions, helping the disabled, and audio games

TheCognivox VIO-1003 comes completely assembled in an attractive 5- by 6- by 1¼-inch plastic case. The device plugs into the game-paddle I/O (input/output) port of the Apple and operates from a 9-volt power supply provided with the device.

The Cognivox contains an internal amplifier and speaker but also has an audio output jack for use with a higher-quality amplifier system. Voicetek provides a 120-day repair-or-replacement warranty on the Cognivox. Perhaps the best part of the system is the disk included in the package; it has several programs that allow you to save and restore vocabularies and play games. The Cognivox system requires the Apple II, 48K bytes of memory, and DOS 3.3 (16 sector).

Getting Started

If you're like me, the first 10 minutes after the delivery of a computer peripheral can be very dangerous—you're extremely tempted to experiment with the hardware first and study the instructions later. But with the Cognivox you've just got to take time to read the first few pages of the 26-page Cognivox *User Manual*. All installation steps are explained in detail, but here is a summary of what gets your computer up and listening:

- First, plug the power supply into both the Cognivox and the wall outlet.
- With the computer off, plug the Cognivox into the game I/O port of the Apple.
- Next, plug the microphone into the Cognivox and set the volume control.
- Now boot the Apple using the program disk provided with the system.
- Type "RUN PROG4" and away you go.

When the system is booted you are provided with a menu of the disk selections. In addition to the main program (PROG4) Voicetek also includes four demonstration programs (I'll explain more about these later).

PROG4 is a demonstration program that immediately allows you to digitize your voice for voice output or speech recongition. You can also save or recall stored vocabulary from the disk. Let's imagine that you want to record a speech-recognition vocabulary. The program will prompt you with the question "How many words are in this vocabulary?" You may enter up to 32 words. Digitized words must be greater than 150 milliseconds (ms) and less than 3 seconds in length. The silence gap between words is 150 ms. Voicetek warns that to achieve maximum speech recognition you must enunciate clearly and distinctly. When training is complete a playback option for each entry is provided that allows you to check the clarity of your entries. You can then test the system's ability to detect words corresponding to its stored vocabulary by speaking the words you just stored. The program will display each word it recognizes on the screen. (Remember that the system is trained to one person's voice, and others pronouncing the same words might be rejected.)

To test the system's ability to recognize digitized words, I performed two tests. One test used a vocabulary of 32 words that I entered; some of these entries were similar in sound. The second test used the same vocabulary, but my wife pronounced the words. The results are shown in table 1. Notice that the Cognivox recognized every word spoken by the trainer. This recognition rate of 100 percent is better than that claimed by Voicetek (98 percent). My wife was not as well received; the Cognivox recognized 8 words correctly, 7 in-



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daisy wheel	daisy wheel	business
interface	interface	(no response)
graphics	graphics	graphics
digital	digital	(no response)
editing	editing	interface
computer	computer	computer
conclusions	conclusions	conclusions
analog	analog	(no response)
acquisition	acquisition	(no response)
harmony	harmony	monitor
directory	directory	(no response)
byte	byte	free
Apple	Apple	call
encyclopedia	encyclopedia	(no response)
inexpensive	inexpensive	(no response)
import	import	(no response)
call	call	call
heart	heart	(no response)
technology	technology	(no response)
sales	sales	(no response)
free	free	free
technical	technical	technical
costing	costing	(no response)
cost	cost	heart
matrix	matrix	(no response)
mountain	mountain	(no response)
monitor	monitor	graphics
BASIC	BASIC	(no response)
Pascal	Pascal	Pascal
professional	professional	(no response)
business	business	(no response)

Table 1: *Voice response test results. The Cognivox had been programmed to respond to voice A (the author). When voice B (the author's wife) replaced voice A, the Cognivox usually responded with the wrong word or gave no response. The first column of the table lists the words actually spoken by both voices; the second and third columns show how the Cognivox interpreted voice A and voice B, respectively.*

correctly, and failed to respond to 17. This is to be expected, of course, because the device works with masks of the trainer's voice.

Demonstration Programs

The four demonstration programs included on the Cognivox program disk are VDUMP, VTRAP, VOTH, and TONES.

VDUMP is a voice-output program that reads selected locations of the Apple's memory. You enter the vocabulary (the hexadecimal numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, alpha, bravo, charlie, delta, echo, and fox), select the area of memory for review, and listen as the computer reads its own memory in your voice.

VTRAP is another voice-output program. This one is in the form of an entrapment game. You enter a vocabulary of words that will control the moves of your player on the video display. To move in a particular direction you merely speak into the microphone and the player responds.

VOTH is an interactive game program that allows you and the computer to speak with each other. *VOTH* is actually the game of Reversi (also known as Othello). In this game the computer decides where it will place its piece and tells you the location. When you are ready for your turn, you tell the computer the coordinates of the location for your game piece.

TONES is actually not a demonstration program by itself. If used in conjunction with PROG4 or your own program, TONES permits dialing a Touch-Tone (a registered trademark of the Bell System) telephone with a simple connection to the phone line. TONES contains the corresponding tones for each of the 12 buttons on the telephone. By selecting the correct sequence, any number can be dialed.

Your own programs can be adapted to have voice output or speech recognition by following the steps provided in chapter 3 of the *User Manual*. Several routines are provided in the manual that can be spliced into your main program. These routines assist you in training the Cognivox to recognize your voice, developing a vocabulary for response, and setting memory locations. The instructions are clear, but you will probably have to read them twice before attempting the actual installation.

Applications

The Cognivox could be used effectively in several applications, including security systems, aiding disabled persons, and games.

Because the Cognivox is trained to recognize voice patterns, it could be installed in security systems in place of key and combination locks. The device could be programmed to select a sequence of five words at random from a stored vocabulary. The person wishing to gain entrance to a room, safe, or computer would have to match the recorded patterns. (As shown in my test results, my wife would have a hard time getting into the family safe if it were protected in this fashion.)

Because the Cognivox operates in the audio mode and thus permits communications with the computer without the necessity of a video display or keyboard, applications for disabled persons abound. Using just the voice-output mode, the Cognivox could be helpful to those with poor eyesight. Blind people could communicate with the computer using the keyboard for input and the Cognivox for output. People unable to use the computer's keyboard could use the speech-recognition mode to communicate with the computer; the computer could either speak back or offer a display on the video screen. Now that government and educational institutions are becoming more and more committed to helping the disabled, Cognivox could play a significant role in training these people in computer science and computer-related occupations.



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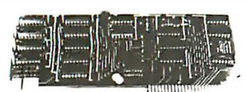
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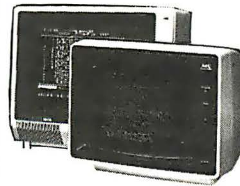
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The Cognivox's potential extends to game applications as well. The two games included on the demonstration disk should only whet the appetite of game enthusiasts everywhere. Imagine moving game pieces by using a microphone instead of the keyboard. Computer graphics could be twice the fun if you controlled the sketching by yelling "up," "down," "left," "right," and so on. Think how exciting a game of vocal chess might be.

System Limitations

A number of limitations in the system become apparent after a few minutes of use. First, the audio quality of the built-in amplifier and speaker is awful. Voicetek recommends that the Cognivox be connected to a high-quality stereo system for improved performance. The only problem with this suggestion is that my stereo system is on the second floor and my office is on the first floor. The poor quality of the audio should have the highest priority for the first revision of the product.

Voicetek promotes the interface of the Cognivox to the Apple by declaring, "It plugs into the game I/O port in the Apple and does not use up the valuable peripheral slots." Now that's a clever advertising ploy of accentuating the positive while downplaying the negative. Most of us have a peripheral slot or two to spare, but how many game I/O ports did you get with your Apple? If the Cognivox is installed, you must give up your joysticks, game paddles, and simple computer control of output circuits. This is a major loss if you want to control motors or relays from a vocal alarm circuit. It also limits how far you can go in flexible game design because you must give up the push buttons.

I decided to take the Cognivox apart to see what Voicetek had used for an audio amplifier; the two screws holding the unit together weren't much of a challenge. It looked like someone had spilled a milkshake on the inside of the case: all the critical parts had had their numbers either filed off or coated with a hard plastic material. The Cognivox must be the hardware counterpart of the protected disk. If you have ever lost a chip or two because of static electricity, you know how convenient it is to be able to quickly repair your equipment by direct substitution of components. You won't be able to do this if the Cognivox breaks down; you'll have to return the device to the factory for repair, which will cost you time and money.

Conclusions

The Cognivox VIO-1003 is what the manufacturer claims it to be—a state-of-the-art speech-recognition and voice-output peripheral for the Apple II computer. The Cognivox records voice masks during a training session and stores these on disk for future voice output or speech recognition. Once trained to a voice, the recognition rate is very high (98 to 100 percent) for a device that uses approximately 4K bytes of storage for programs and tables.

The Cognivox should open new vistas for security systems, aid to disabled persons, and computer games. ■

The Abilityphone

William L. Rush
817 C St., Apt. 1
Lincoln, NE 68502

I had awakened in the middle of the night with stomach cramps. To an able-bodied person, getting up would have posed no particular problem. But I have athetoid cerebral palsy: I'm a person who is a quadriplegic as well as unable to speak. As a result, an otherwise minor case of cramps became a cause for alarm.

I waited and prayed for the attack to subside. When it didn't, I groaned, hoping I could arouse the student assistant for my dorm floor. I hated to wake him up at 2 a.m., but I didn't have much choice. The cramps grew stronger and more frequent by the minute, and sweat began running off my body. Why hadn't I taken a class in Lamaze breathing? Finally, my groans alerted the student assistant, who came into my room and asked, groggily,

"What's wrong, Bill? Are you too hot?"

I shook my head "No."

"Is something wrong with your electric wheelchair and how it's charging?"

"Is something wrong with your voice synthesizer?"

"Is something wrong with your door opener?"

"Is something wrong with your physical body?"

I nodded "Yes" to his last question.

"If I call your attendant, would she know what to do? Great. What's her number? Oh, you can't tell me that, can you? How do I call her for you?" A mixture of frustration and fatigue was in his voice. His training hadn't covered situations like this.

I looked in the direction of my new Abilityphone, which had my personal-service aide's number stored somewhere in its electronic memory. The student assistant only had to push the button marked "Help," and the phone would do the rest. He was trying to find the number when he spied the Help key and asked, "If I push this 'help' button, will the phone give me your aide's number?"

I nodded "Yes." He pushed the button with a picture of a hand on it (so it can be spotted easily in an emergency).

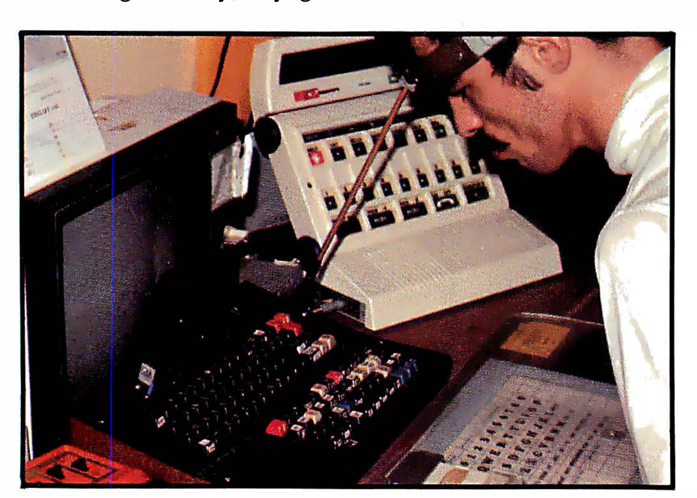


Photo 1: *The author at work. The Abilityphone appears in the background.*

About the Author

William L. Rush is a senior studying journalism at the University of Nebraska-Lincoln as well as a freelance writer. He has a personal interest in electronic aids for people with disabilities because he has cerebral palsy. In addition to the Abilityphone, he uses a personal computer as a voice synthesizer and a word processor.



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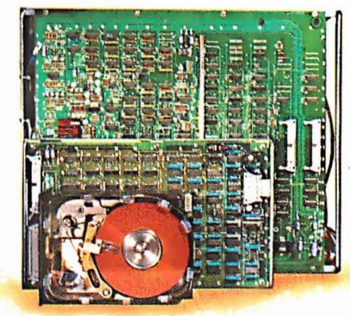
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At a Glance

Name
Abilityphone

Manufacturer
Basic Telecommunications Corporation
4414 East Harmony Rd.
Fort Collins, CO 80525
(303) 226-4688 (Voice/TDD option)

Price
$2335 (suggested retail price)

Warranty
Two-year limited on all BTC equipment against defects in material and workmanship

Shipping size
13½ by 15 by 3⅝ inches

Weight
8½ pounds

Other physical characteristics
32-character alphanumeric display; 1½-hour battery backup; adjustable-membrane keyboard with 22 keys that responds to as little as 5 ounces' pressure for activation; Lexicon plastic housing; brushed aluminum base panel that accepts 2.5 mm external switch jacks, 3.5 mm audio output jacks, modular phone jack, and modular headset jack

Software needed
None

Audience
Anyone interested in devices that assist individuals with disabilities of all types; people with disabilities who have unique telecommunications problems

What happened next reminded me of something from a science-fiction movie. The 13½- by 15-inch Lexicon plastic phone said "Help on" in a clear and computer-generated voice to confirm that the Help function had been activated. Then it calmly (at least one of the three of us was calm) said, "I am calling for help now: calling help number one."

As it spoke, a 32-character alphanumeric display flashed the messages so that if I had been deaf I would have been able to understand what it was doing. Next, I heard my personal-service aide's phone ringing through the speaker (the Abilityphone does not have a conventional receiver). When my aide, who lives in an adjoining dorm, picked up her phone, my phone again spoke in its electronic voice: "There is an emergency at 8117 Selleck . . . forced entry is authorized."

My aide had a Help-Answer beeper, which sent a message to the Abilityphone terminal that help was on the way. The phone, in turn, flashed a message to that effect on its display. Had my aide failed to answer the phone within five rings, the Abilityphone would have called another help number until it heard the beeper.

When the crisis was over, I marveled at how far the art of computer technology has progressed in helping people with disabilities to live outside institutions or nursing homes. The Abilityphone, made by Basic Telecommunications Corporation (BTC) in Fort Collins, Colorado, is a prime example of what can be done with a dual-microprocessor-based system, persistence, and some luck.

The luck came in when I was selected as one of ten people to participate in a three-month field testing of the phone in May 1981. My first reaction to the concept of the Abilityphone was that it was too good to be true. But it sounded interesting, and I had learned not to underestimate the potential of electronics. Besides, I was interested in anything that would improve my ability to communicate.

Workshop for "Test Pilots"

BTC invited me to a workshop designed to familiarize the "test pilots" with the new telecommunications device. We learned that the Abilityphone can answer itself automatically, dial and redial a number by itself, and function as an alarm clock, a four-function calculator, an environmental controller, and a calendar. It can even remind its user to take daily doses of medication. The terminal includes more than 40 features.

Some time after the workshop, I learned that this phone was the result of a six-month market-research study done in 1974 by BTC corporation president Tom Cannon, then a human-factors and product-development consultant. The study, designed to determine the special telephone needs of people with disabilities, concluded that there was a "significant" need for special telephone devices. According to Cannon, the study was not intended to result in a specific product but to identify specific telephone problems of people with disabilities.

Developing the Abilityphone

In 1974, four major obstacles stood in the way of developing a special telecommunications product. Most important, the technology to solve problems raised by the study wasn't available. Even if it had been, the people who could benefit most from it were the most difficult to reach because of social service agencies' privacy-protection policies. Additionally, those who needed the product often could not pay for it, and third-party sources of money, such as insurance companies, were reluctant to assist paying for it. Finally, the product would have had to be sold through existing phone companies, which then did not have the experience to deal with the unique needs of people with disabilities.

But between 1974 and 1978, many changes had taken place that made designing a special device for individuals practicable. New technologies, such as microcomputers, were available at a reasonable cost to provide solutions to many problems. New laws and regulations made equal opportunities for those with disabilities a reality, not just a dream, and people with disabilities were demanding to be treated as equals. In addition, government deregulation of the telephone industry opened the field for companies to sell new products to be hooked up to telephone lines.

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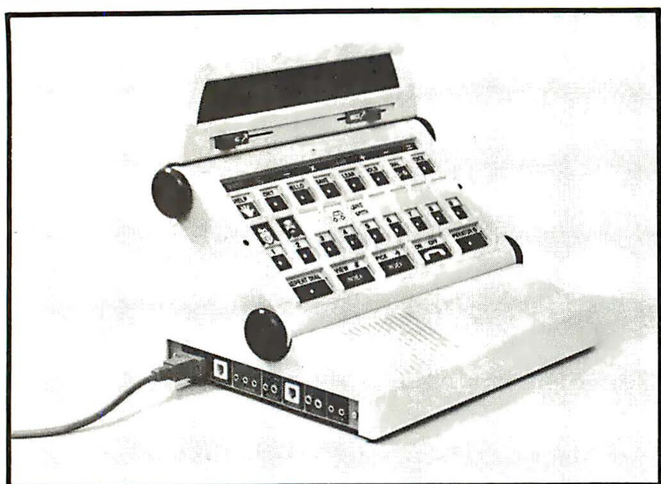


Photo 2: *The Abilityphone. Note that the keyboard and display sections can be tilted at any angle. The membrane keyboard adjusts to respond to as little as five ounces of pressure. A fluorescent alphanumeric display of 32 characters is standard.*

These developments encouraged Tom Cannon to recommend that BTC develop a simulator that would allow the corporation to test its ideas for solving the telecommunication problems of disabled individuals. Such a simulator incorporated a home computer, and people with various disabilities were asked to test the simulator for three months. Another version of the simulator was portable and consisted of a computer in a suitcase, which took 18 months and about 6000 man-hours to build and test. BTC took the suitcase simulator to rehabilitation and independent living centers across the country to get more feedback.

The goal of the simulators' designers was to build a product that would serve people with all types of disabilities so that it could be mass produced and, as a result, more affordable.

The Finished Product

In March 1981, at the American Occupational Therapy Conference in San Antonio, Texas, BTC unveiled the result of more than three years and 24,000 man-hours of work. In the five months that followed, BTC went into full-scale production. During this time, the Abilityphone underwent a battery of tests by an independent testing laboratory that made sure it met a wide variety of governmental and other standards.

The Abilityphone uses two microprocessors. The main one is an RCA 1802. The terminal contains 24K bytes of ROM (read-only memory) and 4K bytes of RAM (random-access read/write memory). In addition, all I/O (input/output) devices are memory-mapped. The RAM, ROM, and I/O all reside in the lower 32K bytes of the processor's address space.

The second microprocessor is an Intel 8048 with on-chip RAM and ROM. It is a peripheral processor that monitors the phone line and performs the environmental control functions (the unit will send commands to any BSR remote-control module). The terminal uses prioritized interrupts. The main processor and peripheral processor are set up in a master-slave arrangement. When the master sends a command to the slave, it causes an interrupt to occur on the slave. When the slave has finished its task, it sends a status message back to the master.

The Abilityphone's I/O devices include a membrane-style keyboard (see photo 2), but it doesn't have a full alphanumeric or typewriter keyboard. It uses a fluorescent alphanumeric display that is readable at about 20 feet. It has a serial port and a modem. A speech synthesizer, also included, has a limited vocabulary and is not a true phonetic synthesizer. More memory can be added to increase the unit's vocabulary. Figure 1 shows a block diagram of the Abilityphone.

BTC does a thorough "burn-in" on every terminal to check for faulty components. Testing takes from six to eight hours.

Features

The following is a selective list of some of the Abilityphone's features.

Emergency dialing. The Abilityphone will dial up to six predetermined phone numbers in sequence when the user pushes the Help key. Depending on the options selected on the terminal, the Help message can be either spoken or transmitted as data. The party called can respond with a Help-Answer beeper.

Monitoring. At predetermined times, the Abilityphone can ask, "Are you OK?" If the user doesn't respond with-

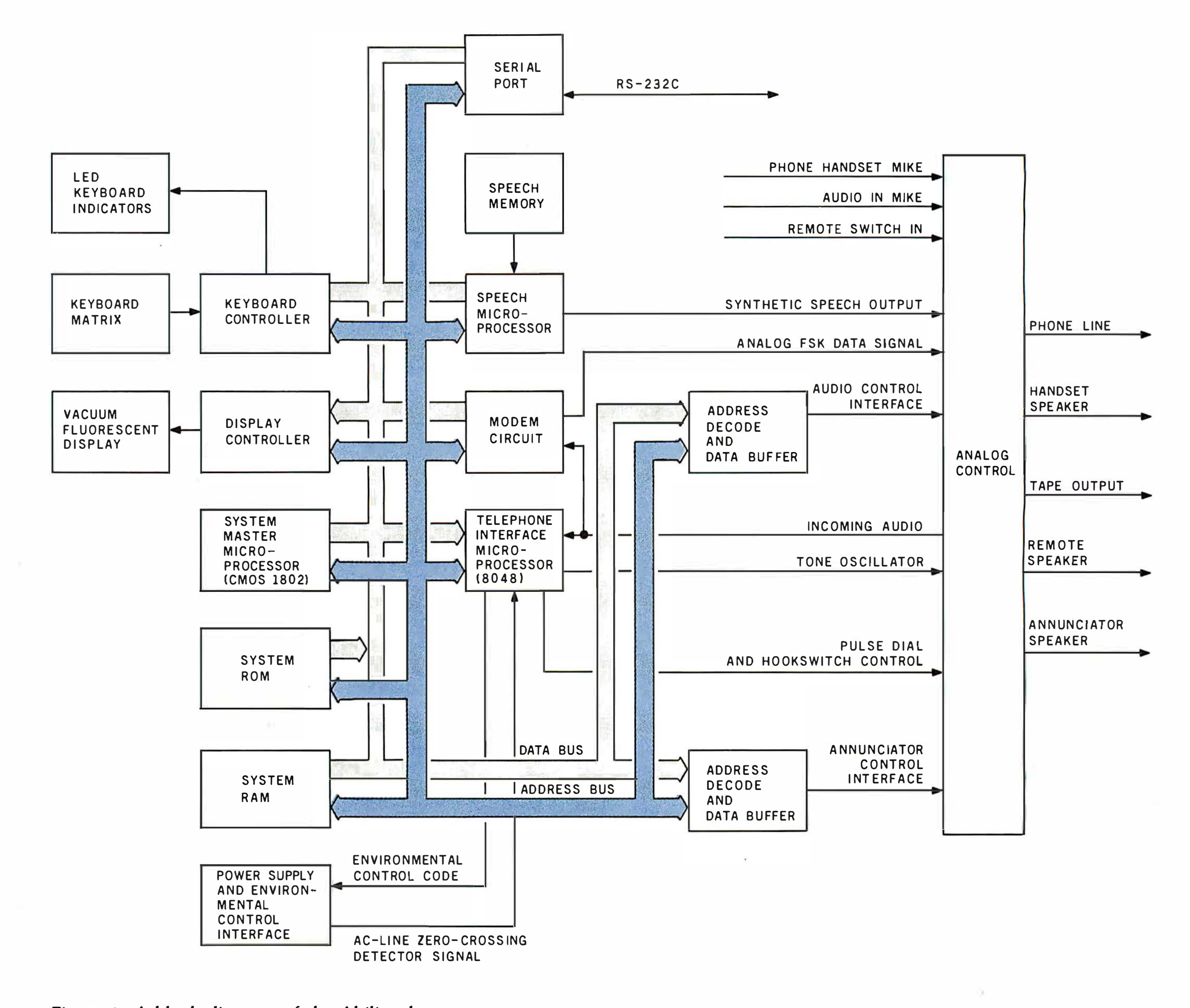


Figure 1: *A block diagram of the Abilityphone.*

in five minutes, the Abilityphone dials an emergency number. This assures the user that help will be summoned even if he or she can't get to the phone.

Reminding. The Abilityphone can be set to remind the user at predetermined times to perform routine tasks that are necessary to prevent a crisis. This function is ideal for providing prompts to take medicine, eat special meals, or change position to avoid pressure sores.

Automatic answering. After three rings, the Abilityphone will answer itself, allowing the user with limited mobility additional time to get to the phone.

Repeat dialing. When a dialed number is busy or the party called fails to answer, the Abilityphone will redial the number until the party is reached.

Conclusion

You might wonder if all the time and effort that goes into building such equipment is worth the benefits to its users and to society. I can't answer the question for society. I can only hope society sees that through the use of such equipment, it will gain more productive members.

As a user, however, I can attest to the Abilityphone as invaluable. Of all my electronic devices (electric wheelchair, door opener, and computerized voice synthesizer), the Abilityphone makes me feel most secure. One of its 40-odd features, a monitoring function, is a good example. I can set it so that, at predetermined times, the terminal can ask me, "Are you OK?" Then if neither I nor an aide presses one of its 22 keys within 5 minutes, the phone will call for help on its own.

I used to panic when my morning personal-service aide was 15 minutes late to get me out of bed. Now when that happens, I wait serenely to hear the phone say, "Are you OK?" And if nobody answers its musical ring within five minutes, it announces, "I am calling for help now. . . . "■

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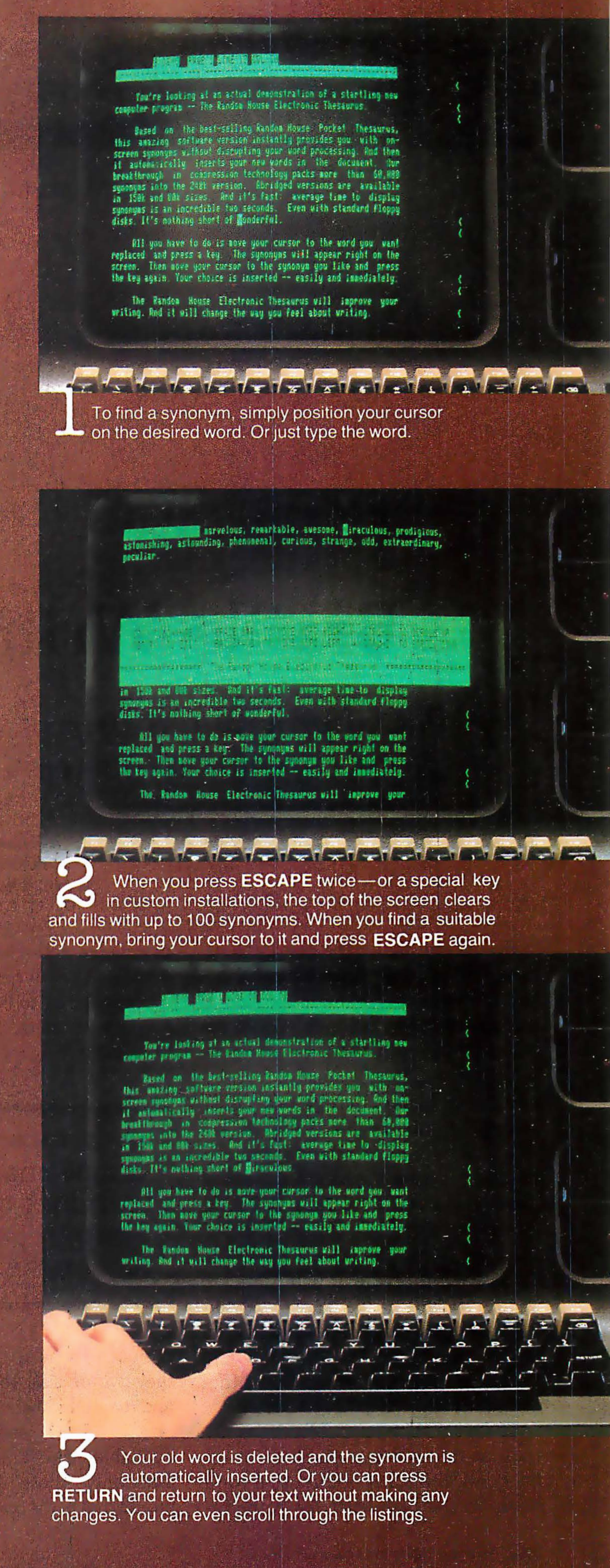
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State ____________ Zip ____________

Computer Manufacturer ______________________

Operating System ____________ Disk Size ____________

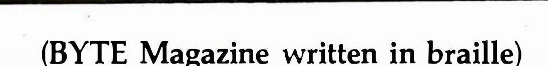
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1 To find a synonym, simply position your cursor on the desired word. Or just type the word.

2 When you press **ESCAPE** twice—or a special key in custom installations, the top of the screen clears and fills with up to 100 synonyms. When you find a suitable synonym, bring your cursor to it and press **ESCAPE** again.

3 Your old word is deleted and the synonym is automatically inserted. Or you can press **RETURN** and return to your text without making any changes. You can even scroll through the listings.



(BYTE Magazine written in braille)

Braille Writing in Pascal

A Pascal program, a strip of cellophane tape, and a rubber glove combine to make a line printer write in braille.

Alfred Fant Jr.
POB 26284
Austin, TX 78755-0284

Braille writing for the blind was developed by the Frenchman Louis Braille, who was himself blinded at the age of three. Since the invention of his language in 1824, thousands of books, magazines, musical scores, and other literary works have been translated into braille. One of the most ambitious translation projects to date has been the braille edition of the *World Book Encyclopedia* by the American Printing House for the Blind in 1961. The largest project in the history of braille, it will probably be the last time such a large undertaking is done by hand. The final edition of the encyclopedia contained 136 volumes—truly, a magnificent accomplishment.

Today, numerous publications are translated into this readable print for the blind. Still, it is not unusual for a book on the best-seller list to be remaindered before it is finally brailled. This happens because there is much more material to braille than there is funding to do it. Blind people (and libraries serving the blind) are queried periodically as to what publications they would like to see brailled next and to rank them by priority. The limited funds and computer time available make it mandatory to translate only those publications that would have the greatest readership. Hence, in a situation similar to military triage, many worthwhile books are never translated.

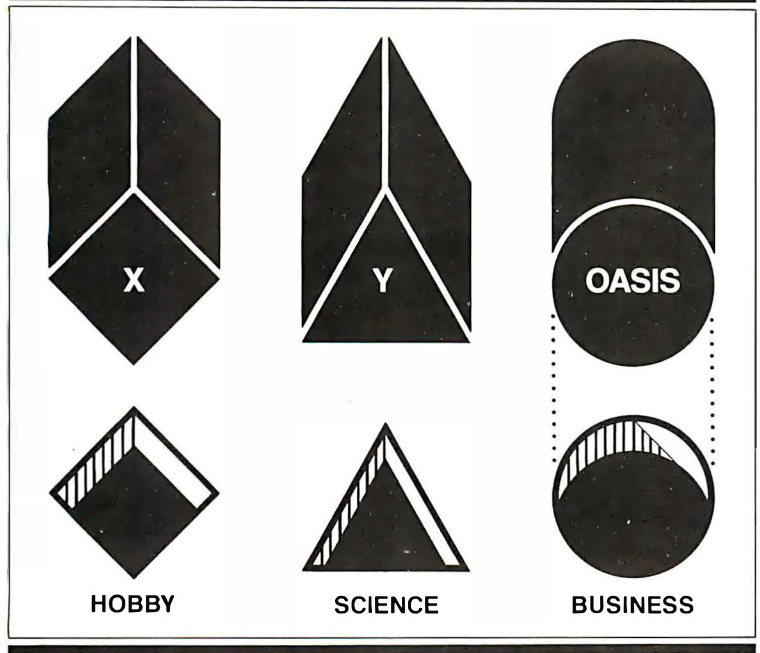
The software treats the braille characters as four lines of graphics output per line of braille type.

My interest in braille translation began when a local Boy Scout troop asked for help in acquiring scouting materials for its new blind members. A survey of the literature found much in the way of audio-tape materials. Unfortunately, precious little material was in braille. The Scouts had found it difficult to use the tape library because they could not readily locate specific topics. You just cannot skim a tape as you can a printed braille book.

I proceeded to learn braille from the instructions given in the Scout Handbook, soon progressed to a college textbook on the subject, and finally purchased a braille machine to use with the visually disabled boys. After months of practice, study, and

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hand-brailling of various scouting materials, I felt there had to be a faster way to translate our literature. Eventually, the idea of a computer translation came to my mind.

While working on a program to graph multifunctions on a line printer, I devised a software method to allow brailling on a standard line printer with no permanent modifications. Basically, the software treats the braille characters as four lines of graphics output per line of braille type. I hasten to add that you have to add a strip of specially prepared cellophane tape to the printer, but it is not necessary to remove the inked ribbon or readjust the printer's impact force. Indeed, regular printer output can be handled concurrently with the braille output.

The Latex Cushion

The devised modification for the line printer had to be simple, quick, and easily removable. The solution was a 9-inch strip of half-inch-wide, double-stick cellophane tape covering a similarly sized strip of thin latex rubber, which was cut from common household gloves used for dishwashing. The best results were obtained by using so-called flock-lined gloves. Place the latex side of the strip against the cellophane tape, leaving the flock lining exposed. Finally, press this assembly into place on the metal platen behind the computer paper. When the printer head strikes the paper, it will leave an indentation because of the minute additional travel afforded by the flock cushion.

Please note that the double-stick tape must be *completely* covered by the latex strip. This is very important because if any part of the tape is exposed, the computer paper will drag on it and cause paper-feeding jams. Of course, if you have a printer that uses a rubber platen (for example, an IBM Selectric), you would be able to eliminate the latex-tape cushion altogether.

The Software

The accompanying program (see listing 1) is written in standard, transportable (we can hope) Pascal.

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Still, we recognize it's a somewhat extraordinary promise.

system. But frankly, we suspect you are probably as intrigued as you could be on the basis of one advertisement.

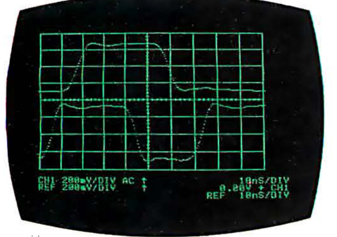
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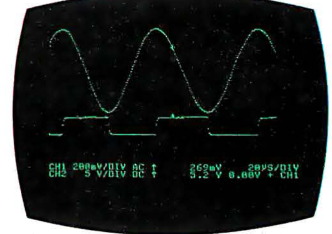
Or simply yield to your initial impulse and order the system, safe in the knowledge that (a) you may use the system for fifteen days, and if not satisfied, return it, and b) NWIS system engineers stand ready to assist you with any questions you may



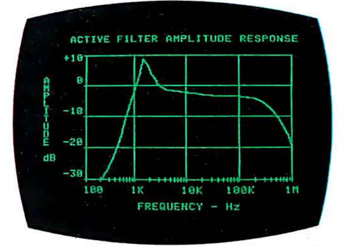
Single keystroke calls aScope™ operations menu. All sub-menus provide complete prompting.



A reference waveform loaded from disk into Channel 2 for comparison with active signal on Channel 1.



Cross-cursor indicates point where aScope™ digital voltmeter (DVM) is calculating waveform voltage for display at bottom of screen.



One example of a user-defined co-resident BASIC program; in this case designed to plot an amplitude response curve for an active filter.

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programmable oscilloscope with a controller when to a great extent the microcomputer circuitry and capabilities of one are already available in the other. So we didn't combine, we integrated. Making the aScope a peripheral part of the computer. Supplying only what was necessary to make the computer a high-performance instrument. An instrument capable of things until now assumed impossible for anywhere near its price.

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Listing 1: *BRAILLE, a Pascal program that converts standard English text into standard Form I braille.*

```
(***********************************************************************)
(*                                                   10/21/81        *)
(*    PROGRAMMER:   ALFRED FANT, O.A.E.                               *)
(*                                                                    *)
(*    PROGRAM:   BRAILLE                                              *)
(*                                                                    *)
(*    ABSTRACT:                                                       *)
(*          THIS PROGRAM IS DESIGNED TO PRODUCE "REVERSE" BRAILLE FOR  *)
(*    USE WITH AN STANDARD LINE PRINTER.   THE BRAILLE CHARACTER ARE   *)
(*    REVERSED TO ENABLE TACTILE READING ON THE BACKSIDE OF THE PAPER. *)
(*                                                                    *)
(***********************************************************************)

PROGRAM BRAILLE;

CONST P='O';      { Your printer may give better results with "O" or "@" }

VAR
 CAPITAL,NUMBER,CELL,FORM,I,J:INTEGER;
 CHARACTER:CHAR;
 TA,TB,TC:PACKED ARRAY [1..80] OF CHAR;
 TEST27,TEST27C:PACKED ARRAY [1..30] OF CHAR;

PROCEDURE CONVERT (VAR CHARACTER: CHAR);

 BEGIN (*CONVERT*)
  CASE CHARACTER OF
         ' ' : CELL:=CELL+2;
         '"' : BEGIN TC[CELL+2]:=P;                      CELL:=CELL+4; END;
         '(' : BEGIN TB[CELL]:=P;  TB[CELL+2]:=P;
                     TC[CELL]:=P;  TC[CELL+2]:=P;        CELL:=CELL+4; END;
         ')' : BEGIN TB[CELL]:=P;  TB[CELL+2]:=P;
                     TC[CELL]:=P;  TC[CELL+2]:=P;        CELL:=CELL+4; END;
         '''': BEGIN TC[CELL+2]:=P;                      CELL:=CELL+4; END;
         '*' : BEGIN TB[CELL]:=P;  TB[CELL+2]:=P;        CELL:=CELL+4; END;
         '$' : BEGIN TB[CELL]:=P; TB[CELL+2]:=P;
                     TC[CELL]:=P;                        CELL:=CELL+4; END;
         '.' : BEGIN TB[CELL]:=P; TB[CELL+2]:=P;
                     TC[CELL]:=P;                         CELL:=CELL+4; END;
         ',' : BEGIN TB[CELL]:=P;                         CELL:=CELL+4; END;
         '-' : BEGIN TC[CELL]:=P; TC[CELL+2]:=P;          CELL:=CELL+4; END;
         ';' : BEGIN TB[CELL]:=P; TC[CELL]:=P;            CELL:=CELL+4; END;
         ':' : BEGIN TB[CELL]:=P; TB[CELL+2]:=P;          CELL:=CELL+4; END;
         '?' : BEGIN TB[CELL]:=P;
                     TC[CELL]:=P; TC[CELL+2]:=P;          CELL:=CELL+4; END;
         '!' : BEGIN TB[CELL]:=P; TB[CELL+2]:=P;
                     TC[CELL]:=P;                         CELL:=CELL+4; END;
         'a' : BEGIN TA[CELL+2]:=P;                       CELL:=CELL+4; END;
         'b' : BEGIN TA[CELL+2]:=P; TB[CELL+2]:=P;        CELL:=CELL+4; END;
         'c' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;          CELL:=CELL+4; END;
         'd' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;
                     TB[CELL]:=P;                         CELL:=CELL+4; END;
         'e' : BEGIN TA[CELL+2]:=P; TB[CELL]:=P;          CELL:=CELL+4; END;
         'f' : BEGIN TA[CELL+2]:=P; TA[CELL]:=P;
                     TB[CELL+2]:=P;                       CELL:=CELL+4; END;
         'g' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;
                     TB[CELL]:=P; TB[CELL+2]:=P;          CELL:=CELL+4; END;
         'h' : BEGIN TA[CELL+2]:=P;
                     TB[CELL+2]:=P; TB[CELL]:=P;          CELL:=CELL+4; END;
         'i' : BEGIN TA[CELL]:=P; TB[CELL+2]:=P;          CELL:=CELL+4; END;
         'j' : BEGIN TA[CELL]:=P;
                     TB[CELL]:=P; TB[CELL+2]:=P;          CELL:=CELL+4; END;
```

Listing 1 continued on page 260

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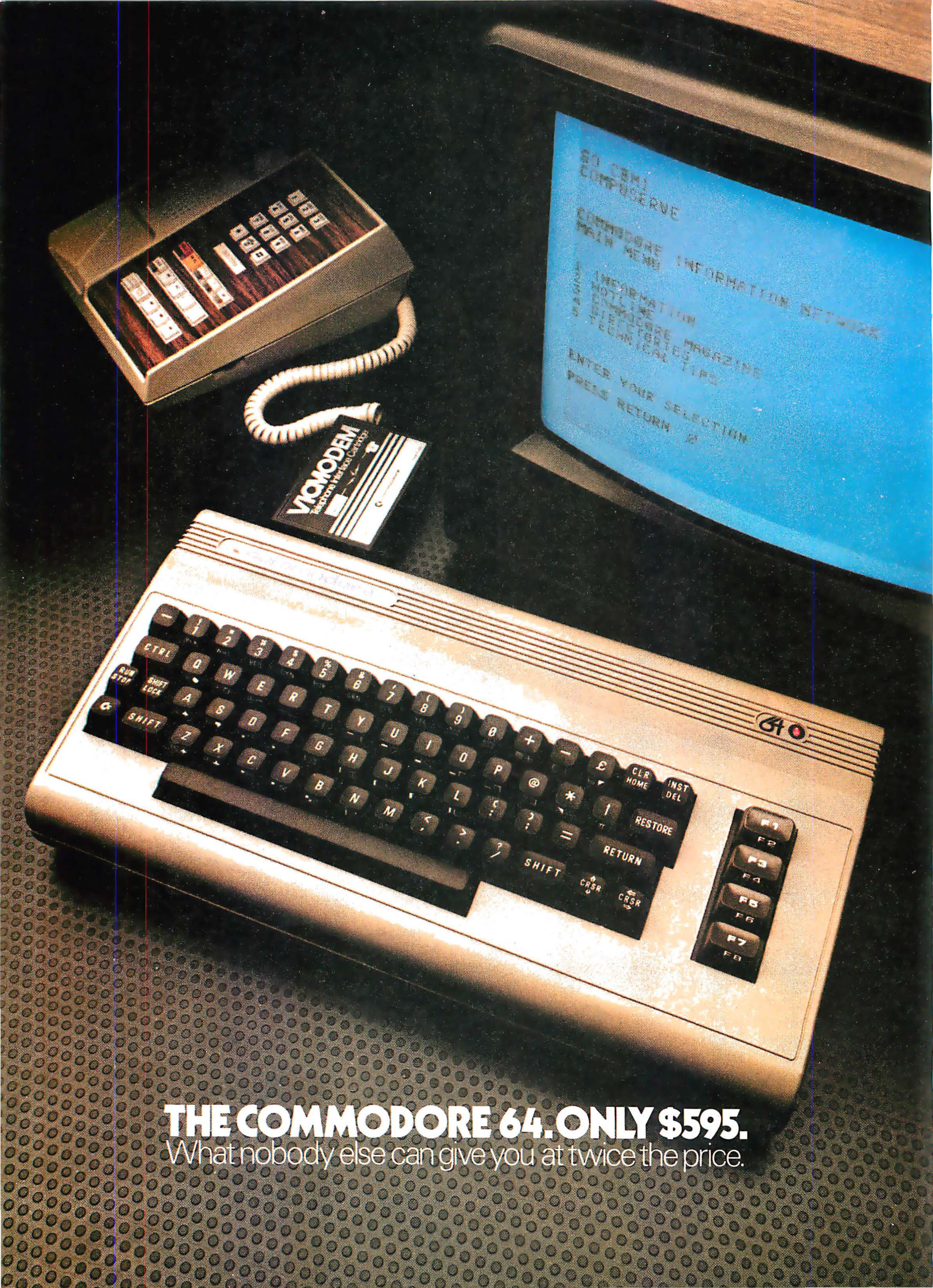


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Listing 1 continued:

```
         'k' : BEGIN TA[CELL+2]:=P; TC[CELL+2]:=P;    CELL:=CELL+4; END;
         'l' : BEGIN TA[CELL+2]:=P; TB[CELL+2]:=P;
                     TC[CELL+2]:=P;                   CELL:=CELL+4; END;
         'm' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;
                     TC[CELL+2]:=P;                   CELL:=CELL+4; END;
         'n' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;
                     TC[CELL+2]:=P; TB[CELL]:=P;      CELL:=CELL+4; END;
         'o' : BEGIN TA[CELL+2]:=P; TB[CELL]:=P;
                     TC[CELL+2]:=P;                   CELL:=CELL+4; END;
         'p' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;
                     TB[CELL+2]:=P; TC[CELL+2]:=P;    CELL:=CELL+4; END;
         'q' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P; TB[CELL]:=P;
                     TB[CELL+2]:=P; TC[CELL+2]:=P;    CELL:=CELL+4; END;
         'r' : BEGIN TA[CELL+2]:=P; TB[CELL]:=P;
                     TB[CELL+2]:=P; TC[CELL+2]:=P;    CELL:=CELL+4; END;
         's' : BEGIN TA[CELL]:=P; TB[CELL+2]:=P;
                     TC[CELL+2]:=P;                   CELL:=CELL+4; END;
         't' : BEGIN TA[CELL]:=P; TB[CELL]:=P;
                     TB[CELL+2]:=P; TC[CELL+2]:=P;    CELL:=CELL+4; END;
         'u' : BEGIN TA[CELL+2]:=P; TC[CELL]:=P;
                     TC[CELL+2]:=P;                   CELL:=CELL+4; END;
         'v' : BEGIN TA[CELL+2]:=P; TB[CELL+2]:=P;
                     TC[CELL+2]:=P; TC[CELL]:=P;      CELL:=CELL+4; END;
         'w' : BEGIN TA[CELL]:=P; TB[CELL]:=P;
                     TB[CELL+2]:=P; TC[CELL]:=P;      CELL:=CELL+4; END;
         'x' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P;
                     TC[CELL]:=P; TC[CELL+2]:=P;      CELL:=CELL+4; END;
         'y' : BEGIN TA[CELL]:=P; TA[CELL+2]:=P; TB[CELL]:=P;
                     TC[CELL]:=P; TC[CELL+2]:=P;      CELL:=CELL+4; END;
         'z' : BEGIN TA[CELL]:=P; TB[CELL+2]:=P;
                     TC[CELL]:=P; TC[CELL+2]:=P;      CELL:=CELL+4; END;
          OTHERWISE WRITELN('ERROR- UNPRINTABLE CHARACTER:',CHARACTER);
  END; (*CASE*)
 END; (*CONVERT*)


BEGIN (*BRAILLE*)
 RESET(INPUT);
 REPEAT
   FOR I:=1 TO 28 DO BEGIN   TEST27[I]:=' '; TEST27C[I]:=' ';   END;
   I:=0;
   J:=0;
   REPEAT
     I:=I+1;
     READ  (CHARACTER);
     TEST27C[I]:=CHARACTER;
     IF TEST27C[I]=' ' AND TEST27C[I-1]=' ' THEN I:=I-1;
     IF CHARACTER IN ['A'..'Z','0'..'9'] THEN J:=J+1;
   UNTIL I+J >= 20 OR (I+J >= 15 AND CHARACTER=' ') OR EOF(INPUT);

                                                      (*****************)
                                                      (* Reverse letter *)
   FOR I:=1 TO 20 DO TEST27[I]:=TEST27C[21-I];        (* order to allow *)
                                                      (* tactile reading*)
                                                      (*****************)

   FOR I:=1 TO 80 DO BEGIN
                       TA[I]:=' ';    (* Intialize Braille *)
                       TB[I]:=' ';    (* Print buffer      *)
                       TC[I]:=' ';
                      END;
```

Listing 1 continued:

```
    I:=0;
    CELL:=1;
    REPEAT
      I:=I+1;
      CAPITAL:=0;              { Flag to indicate capitals }
      NUMBER :=0;              { Flag to indicate numbers  }

                                                     (* Present Braille Cell *)
      CHARACTER:=TEST27[I];                          (* Position number      *)

      IF CHARACTER IN ['A'..'Z']
               THEN BEGIN
                     CAPITAL:=1;
                                (* allows space for capital sign *)
                     CHARACTER:=CHR(ORD(CHARACTER)+32); (*Gives lower *)
                    END;                                 (*case char.  *)

      IF CHARACTER IN ['0'..'9']
               THEN BEGIN
                     NUMBER:=1;
                                (* allows space for number sign *)
                     IF CHARACTER='0' THEN CHARACTER:='k'
                                      ELSE
                                      CHARACTER:=CHR(ORD(CHARACTER)+48);
                    END;

      CONVERT (CHARACTER);

      IF CAPITAL=1 THEN BEGIN
                         TC[CELL]:=P;
                         CELL:=CELL+3;
                        END;

      IF NUMBER= 1 THEN BEGIN
                         TA[CELL]:=P;
                         TB[CELL]:=P;
                         TC[CELL]:=P;  TC[CELL+1]:=P;
                         CELL:=CELL+3;
                        END;
    UNTIL I=21;


  (* DEBUGGING TOOL:   Used to write the English forwards and backwards *)
  (* WRITELN(TEST27C,'                          ',TEST27);             *)


    WRITELN;          (**************************************************)
    WRITELN(TA);      (* Used to write the three line Braille cells     *)
    WRITELN(TB);      (**************************************************)
    WRITELN(TC);

   UNTIL EOF(INPUT)
  END. (*BRAILLE*)
```

Special program functions have been avoided in the interest of disseminating this program as widely as possible.

The listing consists of the main program BRAILLE and the procedure CONVERT. BRAILLE reads a text file character by character until it has 20 letters and/or blanks in its buffer. This restriction of 20 characters is used because only about that many braille cells will fit on the standard 80-column page. BRAILLE then calls CONVERT to translate each character into its corresponding braille cells. However, since capital letters and numbers require two braille cells for their proper interpretation, there will not always be exactly 20 braille cells on each output line. The program continues to loop back and forth between the reading and the translating until the end-of-file marker is reached on the text file. The program then terminates. A sample of the program output is shown in listing 2.

Although the reader obviously can-

90 Percent Perspiration

Almost every story has a "story behind the story," and this article is no exception. Just as Thomas Edison tried thousands of materials for his first light bulb filament before finally discovering his wife's cotton thread, I spent many months trying to come up with the right material for the braille printer pad. It wasn't easy.

I started with a pair of latex surgical gloves and found them to be too thin. Our blind Scouts, reading transcripts prepared with this material, complained that the braille faded after only a few readings.

I therefore tried strips cut from thicker and softer gloves, but the printer then began to jam. No matter how many different materials I tried, nothing seemed to work quite right. The answer had to be there—somewhere.

Success finally came with my discovery that flock-lined gloves were available at the Safeway supermarket. The cotton lining of these gloves provided just the right amount of padding for the computer brailling idea to work. Thomas Edison would have been proud.

not "feel" the indentations on the reverse side of listing 2, this output has been used successfully with the blind Boy Scouts. The monthly troop newsletter is now produced in both braille and regular print. As a result of this newsletter, we have found that the best indentations occur on thicker paper. The indentations are good for only about 15 readings by a blind person, after which the braille becomes too faded to allow correct letter identification. Even so, this method is ideal for short-lived publications such as newspapers and correspondence.

You may have noticed that BRAILLE allows at most only four words to be printed per output line. Though Braille does have a hyphen to mark divided words, it is better to divide as few words as possible. From personal studies of computer dictionaries, I know that five-letter words make up the vast bulk of the English language. Therefore, the program counts characters and looks for a space from the fifteenth to twentieth character (a word break). If a space is found, the line is ended. Otherwise, the line is broken after the twentieth character. Four brailled words may occasionally fit on the line of 20 braille characters, but it is wise to keep a one-word safety margin.

This program produces what is known as Form I or Grade I level braille. In Form II braille, abbreviations are used to increase the number of brailled words per page. These standard braille abbreviations are for often-used words and letter combinations in the English language. This program does not address this question because of memory requirements. On a larger computer, however, it would be easy to program a look-up table for these abbreviations and their braille counterparts. Table 1

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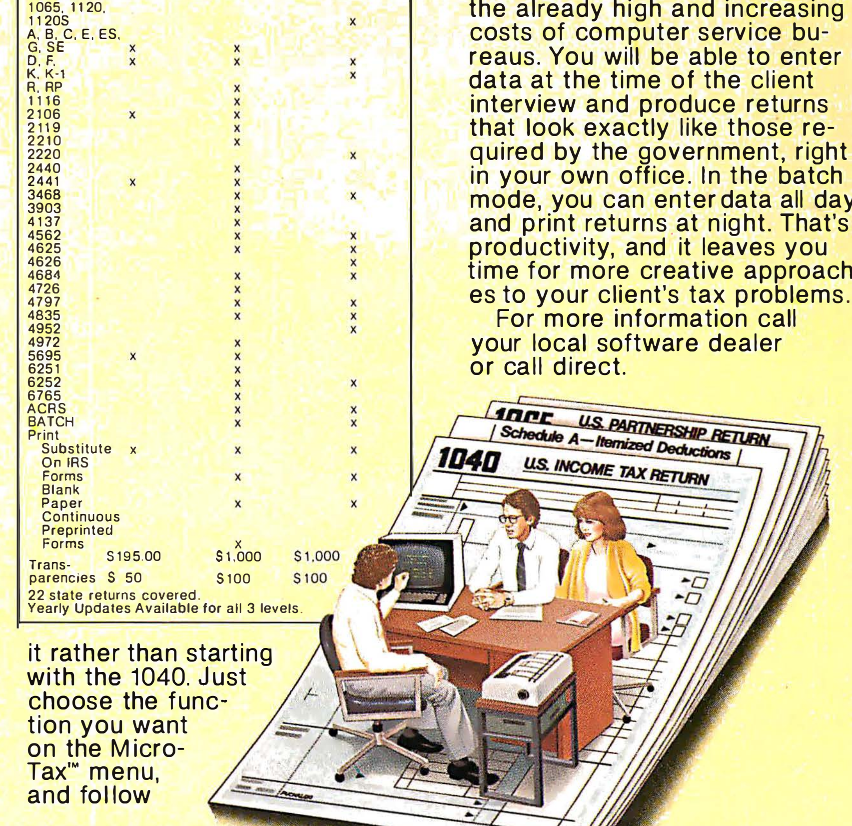
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D, F,	x	x	x
K, K-1			x
R, RP		x	
1116		x	
2106	x	x	
2119		x	
2210		x	
2220			x
2440		x	
2441	x	x	
3468		x	x
3903		x	
4137		x	
4562		x	x
4625		x	x
4626			x
4684		x	x
4726		x	
4797		x	x
4835		x	x
4952			x
4972		x	
5695	x	x	
6251		x	
6252		x	x
6765		x	
ACRS		x	x
BATCH		x	x
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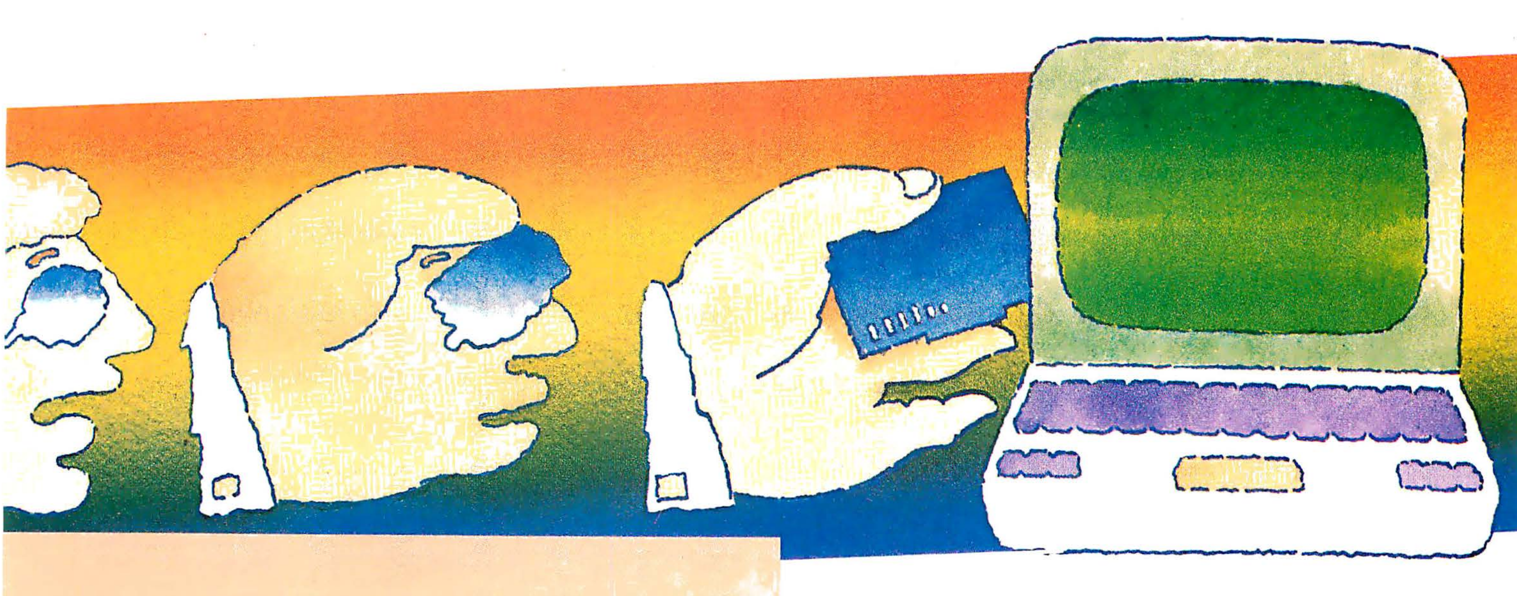
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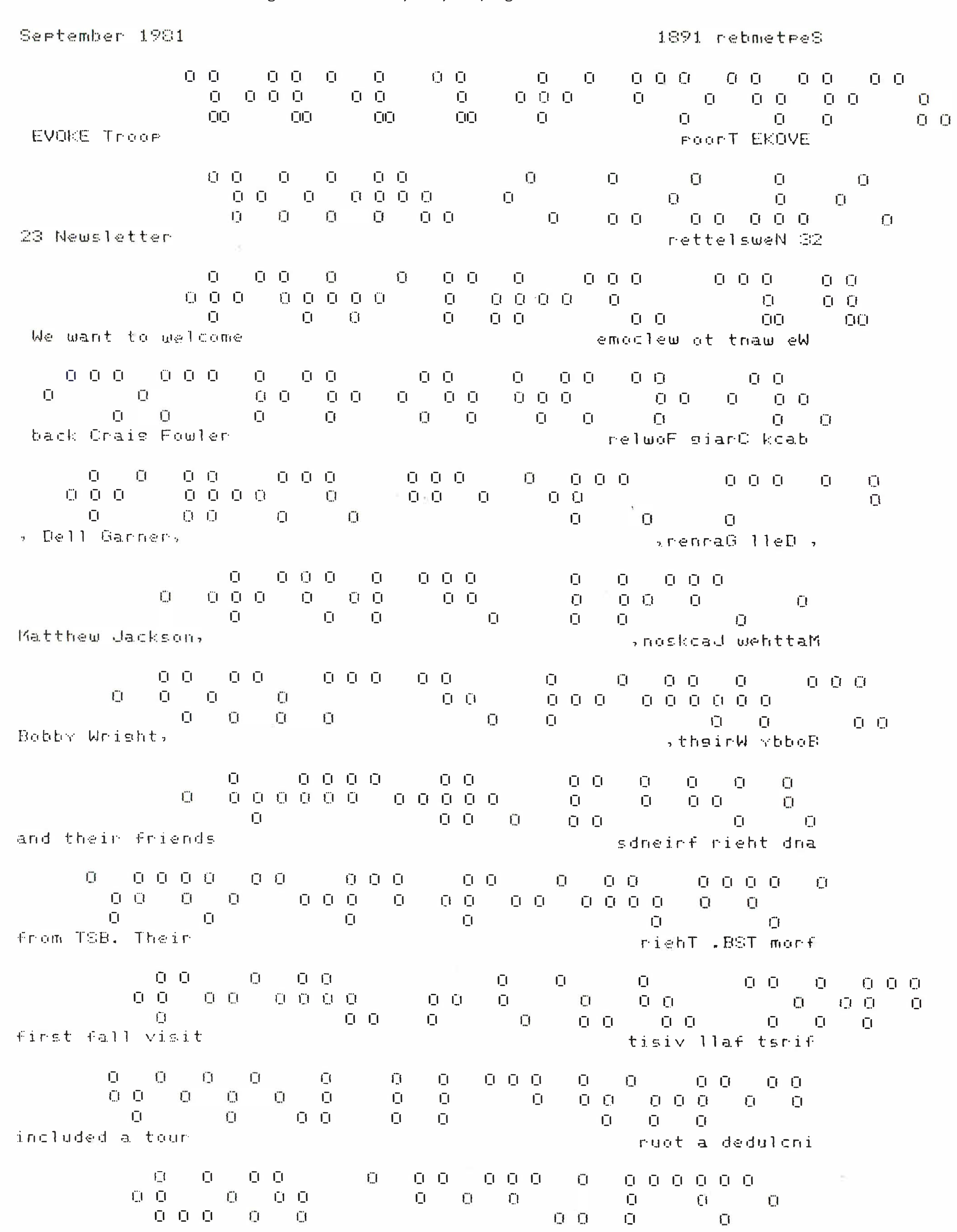




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Listing 2: *Sample output from the BRAILLE program, shown in listing 1. This is the first few lines of the Boy Scout troop's newsletter done in braille type. For the convenience of sighted readers, the English words are printed both backward and forward above the braille text. The text is printed in reverse because the blind reader must turn the paper over in order to read the braille cells by touch. The backward English enables the programmer to check for proper letter order. To keep from confusing braille readers, the programmer should "comment out" the English-written line of the final program.*



a	b	c	d	e	f	g	h	i	j

The braille alphabet starts by using 10 combinations of the top 4 dots. The same 10 characters, when preceded by a special number sign, are used to express the numbers 1 to 0.

k	l	m	n	o	p	q	r	s	t

Adding the lower left-hand dot makes the next 10 letters. Adding the lower right-hand dot makes the last 5 letters of the alphabet (except w) and 5 word symbols, below.

u	v	x	y	z	and	for	of	the	with

Omitting the lower left-hand dot forms 9 digraphs, or speech sounds, and the letter w. This construction continues until all possible combinations have been used.

ch	gh	sh	th	wh	ed	er	ou	ow	w

Table 1: *The braille alphabet and some standard braille abbreviations. (Courtesy* World Book Encyclopedia*)*

shows some of these abbreviations and the complete braille alphabet. (See reference 1 for all the standard abbreviations.)

Conclusion

Braille writing for the blind has been an important contribution of Western civilization. It has brought many blind people into the realm of literature and music. As a programmer, you can now take part in helping the blind to read. Volunteer your computer and time in translating for the blind people in your town. ■

Further Reading

1. Ashcroft, S. C. and F. Henderson. *Programmed Instruction in Braille.* Pittsburgh: Stanwix House Inc., 1963. (An excellent textbook for the adult who has had no previous knowledge of braille. A "learn to braille in 10 lessons" type of book.)
2. Day, Margaret R. "Tactual Mapping and Nonvisual Perception." Master's thesis, University of Texas at Austin, 1976. (A major work in braille mapping, it covers the history of such special maps and the efforts to make them using computers.)

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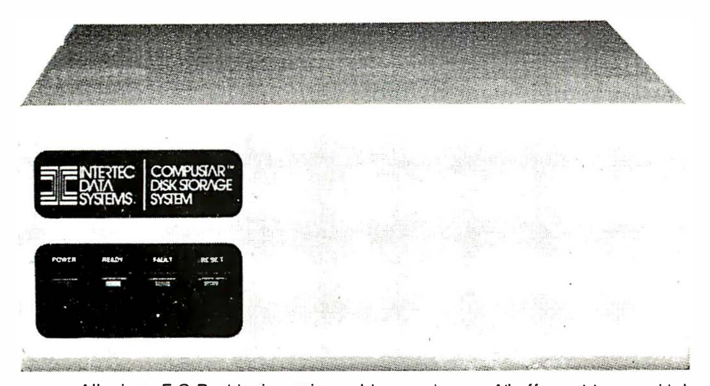
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Computers and the Special Education Classroom

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West Chester, PA 19380

These students enter the classroom one or two at a time. They are in wheelchairs, on crutches, or in bed, because they are patients in a children's orthopedic hospital. Dan, for example, was injured in a diving accident and is now a quadriplegic, paralyzed from the chest down. Bob suffered brain damage in an automobile accident; he is now without speech and cannot walk. His memory and concentration are very poor. Jim has been paralyzed since birth. He was born with spina bifida (a congenital defect of the spinal cord). He is normal in some cognitive skills but lags far behind in others. He gave up trying to learn his "times tables" years ago. These are the students for whom the question was asked, "How can computers be used in a special education resource program serving kindergarten through twelfth grade?" In order to answer this question, an extensive search of available Apple software was made (see tables 1 and 2).

A major concern of special educators has always been the difficulty in getting and holding the attention of brain-damaged or socially and emotionally maladjusted students. The student's attention span is greatly improved when using computer-aided instruction. Large color graphics are excellent attention-getters and are also beneficial for those with impaired vision. Programs that refer to the student by name personalize the lesson and keep him or her stimulated. Finally, the instant feedback on every item in the lesson also helps to sustain the student's attention.

Another need in this classroom is for new and innovative instructional strategies. Many special education students need much more repetition of lessons than "normal" students. This can quickly become tiring for both teacher and student. The computer can relieve this drudgery. A student and a computer can work together, leaving the teacher free to work with others.

Records on each individual student can be kept by the computer, with the scores from drills and quizzes automatically recorded. Instructional lessons and cues can be presented automatically. New programs for microcomputers are even exhibiting branching instructional design. Instead of just a drill, programming can contain extra help in the form of remedial lessons for those having trouble with a particular lesson. For example, a student consistently having problems with reducing fractions would automatically receive a remedial lesson or be returned to a previous lesson that covers finding the greatest common factor of two numbers.

Language development is an important part of the special education teacher's job. Computer speech synthesizers show great promise in helping those with speech defects to monitor and shape their own speech effectively. Recording devices can be built into a program to help in this task by playing a master pronunciation and the student's effort back-to-back for comparison. Computers can also be programmed to recognize regular but unintelligible sounds made by those without effective speech and then to output an intelligible word or phrase that enables the student to communicate. For example, a particular sound at a certain pitch could trigger the computer to output the greeting "Hello!" Finally, programs are available to turn the computer into an electronic communicator. The push of a single button can cause an entire preprogrammed sentence or paragraph to be printed on a monitor or piece of paper, or to be spoken by a voice synthesizer.

Valuable skills can also be acquired or improved by using microcomputers. Many disabled people have gotten started on a career in computer programming with courses in computer literacy and BASIC programming. Motor skills, such as typing and eye-hand coordination,

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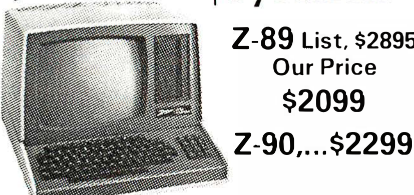
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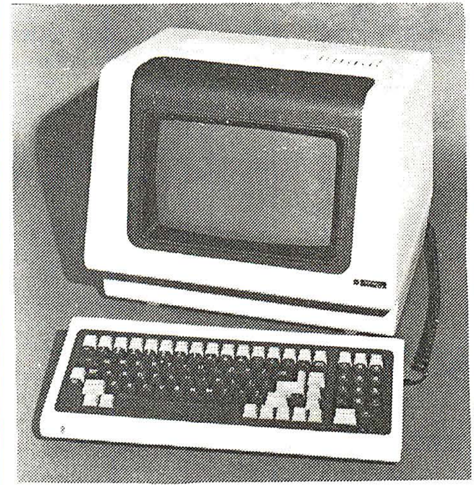
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BM-12. . . . . $159
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Flash Spelling—Teachers may add their own words	$33.50
(Most are self-scoring)	
George Earl 1302 South General McMullen San Antonio, TX 78237	
Spanish Hangman—1600 words and 450 sentences	$29.95
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Grover Associates c/o Scholastic Inc. 904 Sylvan Ave. Englewood Cliffs, NJ 07632	
The Microcommunicator Version C—For a child without speech	$46
The Microcommunicator Version A—Adult vocabulary	$46
Program Design Inc. 11 Idar Court Greenwich, CT 06830	
Pre-School I.Q. Builder—Readiness activities, colors and shapes	$19.95
Vocabulary Builder 1—Beginner—J.H.S.	$19.95
Vocabulary Builder 2—Advanced—S.A.T. preparation	$19.95
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Step-by-Step Course—Computer programming in BASIC with text	$59.95
BLS Inc. 2503 Fairlee Rd. Wilmington, DE 19810	
Arithmetic Fundamentals—Tutor Course 2-5—29 disks	$1479
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Algebra 1—Definitions, Sets, Evaluation Expressions	$39.95
Perception 3.0 Visual Discrimination, Shapes and Length	$24.95

Table 1: *Publishers of educational software packages and their products. These packages have been effective in a special education resource room.*

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At Advanced Micro Digital, we believe in co-operation between computers and their operators. That's why our new team of S-100 master and slave processors are designed with your team in mind and feature superlative reliability and ease of operation.

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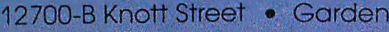
Each SUPER-SLAVE is a powerful single-board slave processor designed for use with the SUPER QUAD in either network or stand-alone configurations. The outstanding features of the SUPER-SLAVE include:

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Gamco Industries Inc. POB 310 P Big Spring, TX 79720-0120 (915) 267-6327	Opportunities for Learning Inc. 8950 Lurline Ave. Chatsworth, CA 91311 (213) 341-2535
The Micro Center POB 6 Pleasantville, NY 10570 (914) 769-6002	Scholastic Software Scholastic Inc. 904 Sylvan Ave. Englewood Cliffs, NJ 07632 (212) 867-7700

Table 2: *Mail-order software retailers specializing in educational software. These retailers can supply most of the software listed in table 1.*

can be taught and evaluated with existing software. Mathematical problem solving, equation writing, and plotting on a graph are just three of the many mathematical skills being taught with the aid of computers. Students can sharpen skills for the S.A.T. or G.E.D. tests. Finally, visual perception, manual dexterity, and eye-hand coordination can be taught through computerized electronic games, accessed through the keyboard paddles or joysticks. These games can be a motivational reward to be earned by students for achievement in other areas.

Computers are highly adaptable tools and endlessly patient teachers. They can give the special education student useful skills to cope with everyday life, a method to communicate his or her needs, and perhaps a brighter outlook on life. ■

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The Effortless Way To Create Your Data Base And Related Applications

The QUAD is a relational data base management system and applications developer allowing the non-programmer to develop his or her own business and personal applications around a powerful relational data base. Some of the applications you can build with the QUAD are:

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- Order Entry
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- Professional Time and Billing
- Property Management
- Sales Analysis

PERSONAL

- Appointment and Gift Register
- Budgeting
- Car Maintenance
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The QUAD is designed for YOU, the computer user who wants to take full advantage of his computer.

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The QUAD enables you to create an unlimited number of reports in any specific size or form you desire using data from the QUAD database or another database. You may process and/or print data during any report.

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- access information in up to *10 or more files* during a report
- perform *arithmetic calculations* on any data from any file
- update and/or create files based on report processing
- easily *compare date* information for quick aging analysis
- perform up to *5 levels of subtotaling* within each report
- retrieve records in *sequential* or *indexed* order
- perform processing based on comparison of data such as nested *IF THEN logic*

PRINTING DATA

- utilize your printer's capability by *printing on any size paper anywhere* on the page
- *print checks* using the English equivalent for dollar and cent values
- specify content of page headings, control headings and footings, detail lines and total lines
- pause between printing of forms

SAMPLE REPORT

AGED RECEIVABLES

ABC CORPORATION
7700 American Way
Seattle WA 98105
06 15 82

CUSTOMER #	CUSTOMER NAME	CURRENT	30-59 DAYS	60-89 DAYS	90 & OVER	TOTAL
0110	AGE Manufacturing	1 500 00	350 00			$ 1 850 00
0210	Blair Fabrication	4 750 87		750 00		5 500 87
1056	Klassic Koins	8 970 00	1 750 00	496 50	970 00	12 186 50
1820	Richardson Doors	754 80				754 80
2501	Yarrow Bay Boat Co	14 778 00				14 778 00
	TOTAL RECEIVABLES	$ 30 753 67	$ 2 100 00	$ 1 246 50	$ 970 00	$ 35 070 17

POWERFUL UPDATING CAPABILITIES

The QUAD gives you two methods to update data within the data base. One way is directly through the terminal using a data entry process. The other is through batch updating based on existing data within the data base.

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- totally *user defined screens*
- *full screen editing*
- record sizes up to *900* characters
- *perform calculations* based on data entered and data residing in other files
- access three different *help screens* during the data entry process
- utilize your terminal's *video capabilities* when creating your terminal update screens
- *restrict* all or some *data fields from* future changes
- *edit each data field* for items such as phone numbers, numeric data, alphanumeric data, date, time, social security number, etc., or your own defined edits
- *IF-THEN logic* available during both terminal and batch updating

SAMPLE SCREEN

```
06/08/82      ADD Order Entry Information      0 of    75 Records

Order Entry Line Item for CUSTOMER #     1005     Klassic Koins
                    Customer's P.O. Number      4325
    Salesperson #      15     Martin Smith

        Item #        C8507
        ITEM          Nuts and Bolts     QTY        100.00
                                         Charge        .50
                                         Extended    50.00

                    Press (ESC)H for Help
```

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SORT, INDEX, and REORGANIZE data files quickly and easily. Also link to user-written programs directly from the QUAD. Automatically generate menus to access each of your applications.

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Circle 524 on inquiry card.

Adaptive-Firmware Card for the Apple II

Alternative input techniques give physically disabled individuals immediate access to standard software.

Paul Schwejda
Alternative Communications Project
Child Development
and Retardation Center
WJ-10 University of Washington
Seattle, WA 98195

Gregg Vanderheiden, Director
Trace Research and Development Center
314 Waisman Center
1500 Highland Ave.
Madison, WI 53706

At the present time, interest is growing in the use of microcomputers to help solve the needs of people with disabling conditions. A number of programs allow individuals to use a computer even though they may be too severely disabled physically to use the keyboard directly.

Presented here is a low-cost adaptive-firmware card that can be inserted into an Apple II microcomputer to provide a variety of "transparent" input routines including scanning, Morse code, and direct selection techniques. (The term "transparent" here indicates that the routines work in conjunction with other programs without requiring that the programs be altered in any way.) In addition to providing "keyboard" input, the card can also simulate the use of game paddles and switches for people who cannot use the game paddles themselves.

A large number of programs have been written that allow disabled individuals to accomplish specific functions with a microcomputer. A variety of special single-switch scanning routines, expanded keyboards, and encoding routines have been developed; some of these programs require only a slight movement of one eye to allow an individual to select words, phrases, or commands from menus presented on the video screen. Most of these programs, however, cannot be used in conjunction with other standard microcomputer software packages. It is not possible, for example, to use many of them to control Visicalc (a spreadsheet program) or to enter characters and words into Easywriter (a text-editing program). As a result, disabled persons are able to tap only part of the potential of microcomputers and the vast world of software that is available.

In order to overcome this barrier and allow physically disabled individuals access to standard software, transparent techniques and modifications are being developed. These allow the disabled user to access the computer in such a way that both the computer and any software written for it function normally, just as if the computer were not controlled through a special input routine. Truly transparent techniques allow total access to any software written for the computer.

One strategy for providing transparent input is the use of a keyboard emulator driven by a separate communication aid or another computer. Although very powerful and very transparent, this approach is costly because it involves the expense for both the emulator module and the communication aid or second computer.

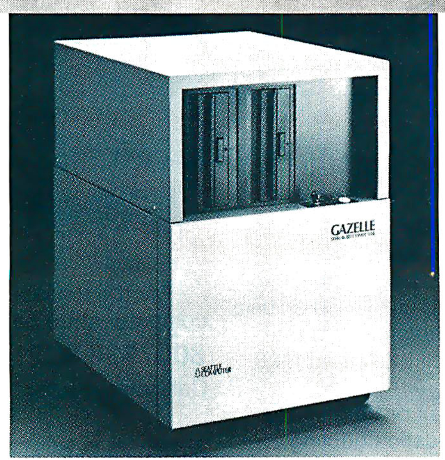
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Call toll-free **1-800-426-8936** for more information. Dealers who have been hunting for a swift and sleek Gazelle are encouraged to call.



Circle 418 on inquiry card.

Basic Description

The purpose of the adaptive-firmware card is to provide completely transparent control of the Apple II to people with severe physical disabilities who are unable to use the keyboard and game paddles in their normal fashion. To accommodate the largest number of individuals, 1 of 10 different input modes may be selected by using a thumbwheel switch on the box mounted to the side of the Apple II (see photo 1). With each of the techniques, the normal keyboard remains active and can be used at any time. Also, a number of options available with the card facilitate its use by offering adjustable timing rates.

The complete interface consists of a specially designed printed-circuit card that is inserted in slot 7 of the Apple II computer and a small plastic box that snaps onto the side of the computer (this contains the input jacks and the mode-selection thumbwheel). The card has a jumper cable ending in a 16-pin DIP (dual-inline pin) connector; it is very similar in appearance to the Apple language card. The DIP connector replaces a decoder IC (integrated circuit) located directly in front of slot 7 and gives the firmware card control over the I/O (input/output) decoding in the Apple.

To install the firmware card, simply remove the 74LS138 decoder immediately in front of slot 7 and insert the jumper plug. Then insert the adaptive-firmware card into slot 7 and snap the interface box to the side of the Apple II. Photo 2 shows the adaptive-firmware card installed. Installation (or removal) takes less than a minute and, unlike that of other keyboard emulators, does not require the removal of the bottom of the Apple, nor does it require that the keyboard be disconnected from the main circuit board; this is done electronically during operation.

Operation

To use the adaptive-firmware card, select the desired output mode with the thumb switch and turn on the computer. The disk will not be loaded immediately; instead, a message will appear on the screen asking for the sampling (timing) rate desired for the input routine. Once the rate is entered, the disk will boot as during normal operation of the Apple II. From this point on, whenever input is required, you may use either the keyboard or the selected special input method. (The selected input method can be changed, as can the rate, simply by resetting the system twice.) Now let's examine the available input modes.

With the switch set in the *normal-keyboard* position, the Apple II acts as if the firmware card is not installed in the Apple. Input is accepted from the keyboard in the usual manner.

With *one-switch scanning*, all input is handled through a single switch. When you press the switch, an array of letters and symbols will appear at the bottom of the screen, and the cursor will automatically begin scanning at the rate previously set. The letters are arranged in groups, and the

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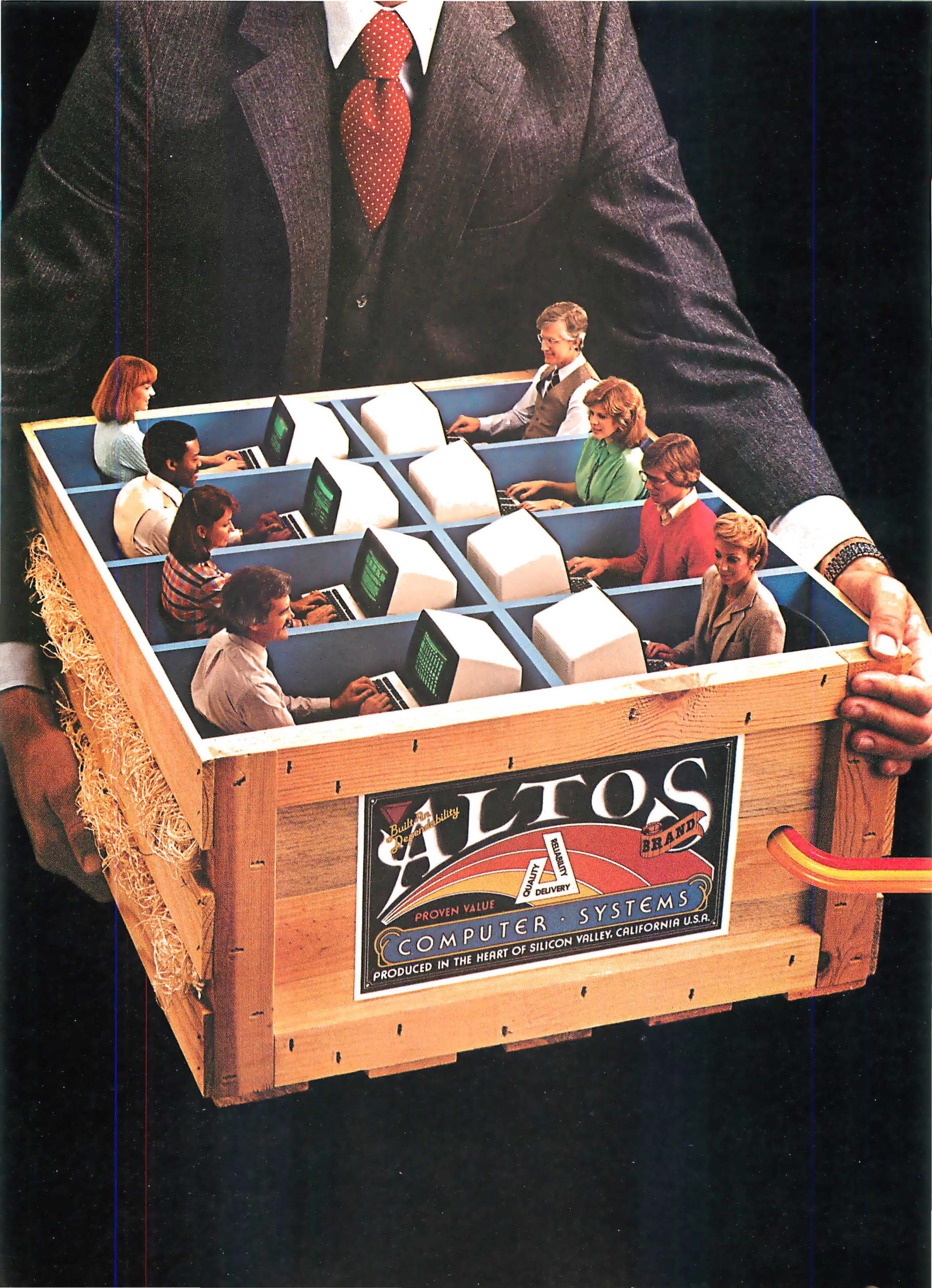
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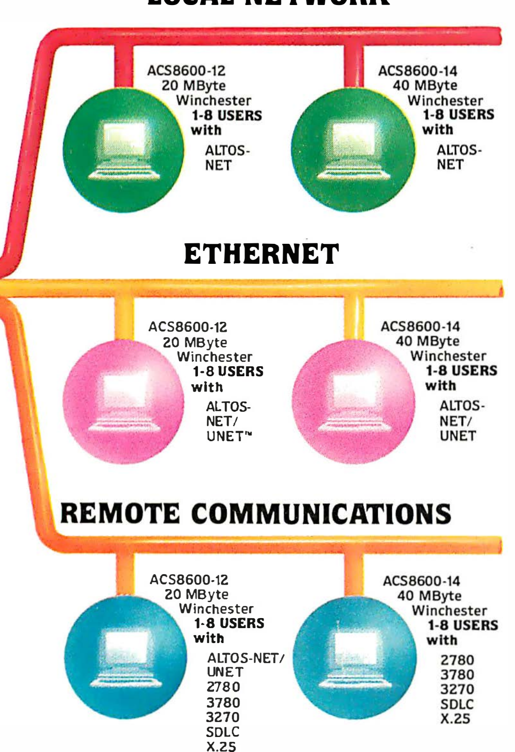
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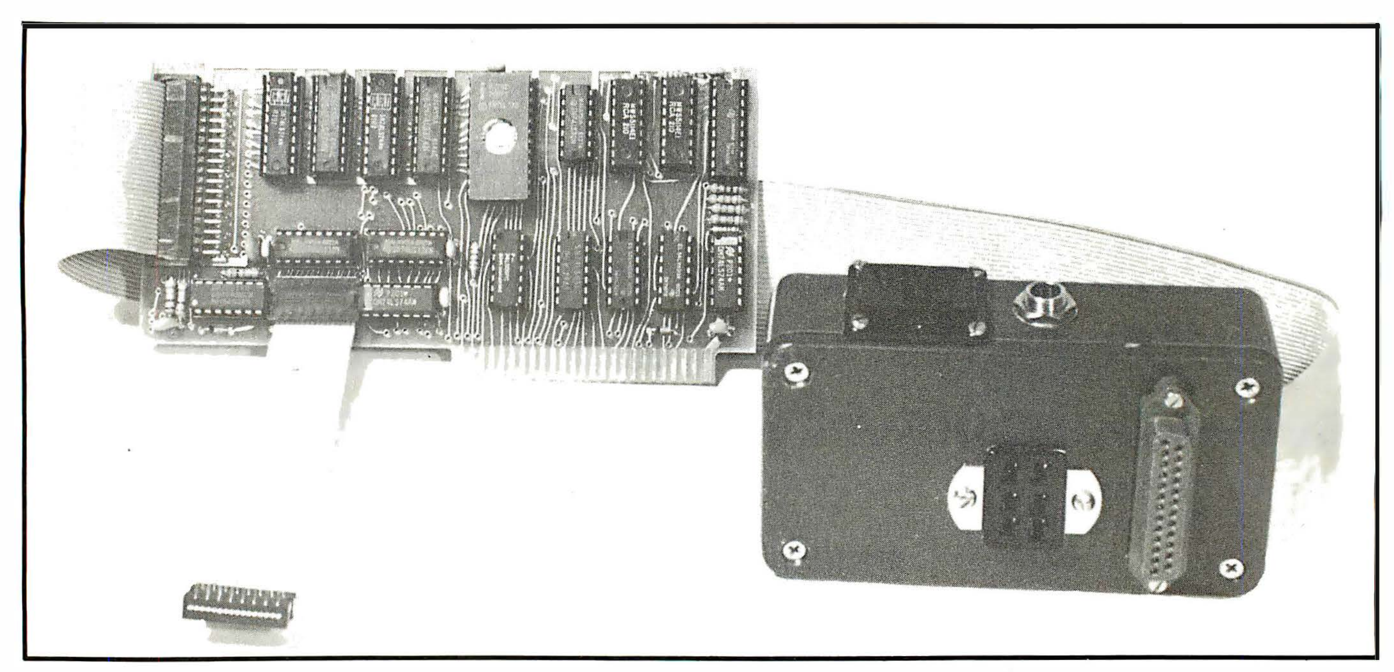


Photo 1: *The adaptive-firmware card. The device allows disabled users to run standard, unmodified software (such as games, Visicalc, Easywriter, etc.) using any of 10 input routines, some of which require use of only a single switch. (Photo by Ed Crabtree.)*

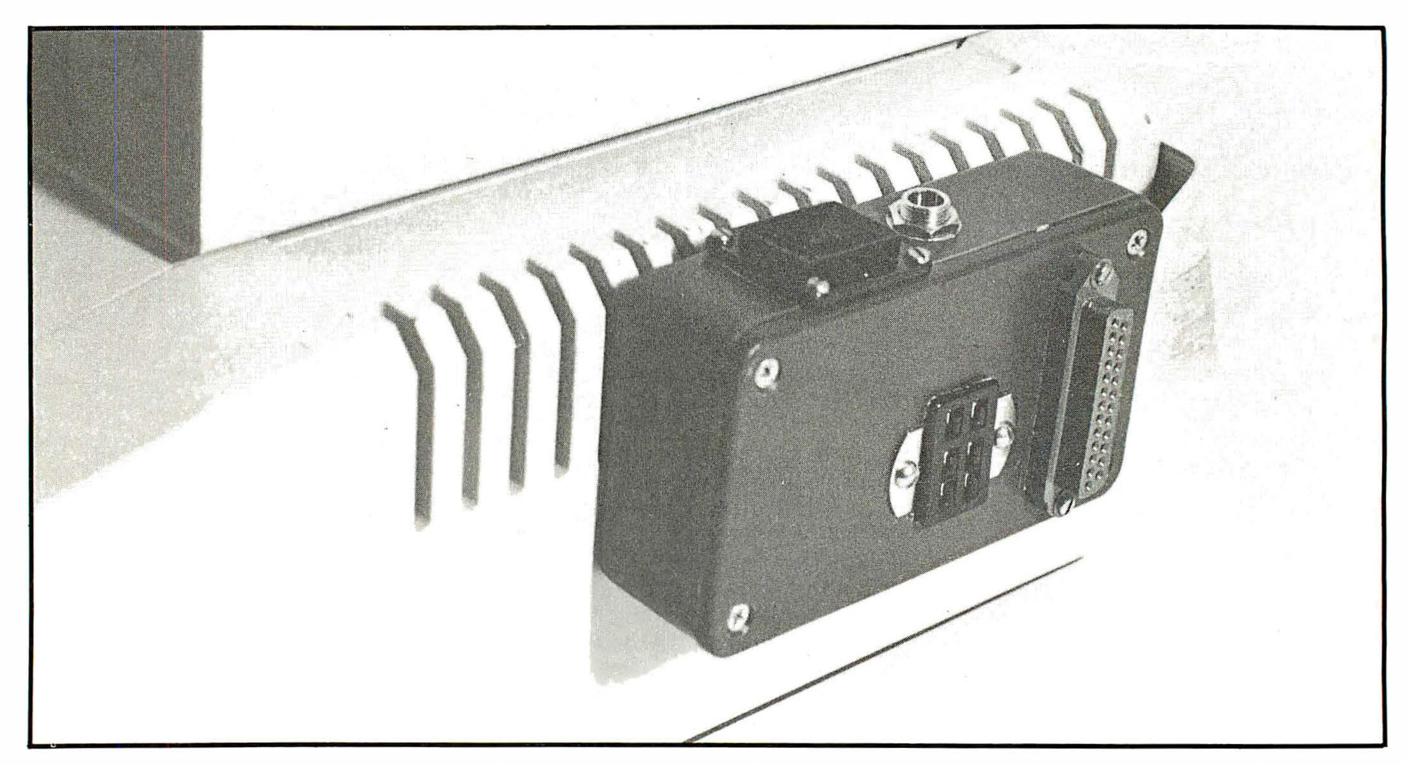


Photo 2: *The adaptive-firmware card as installed on an Apple II. The device plugs into slot 7 of the Apple; it remains hidden to the Apple's system yet allows the disabled user complete access to the Apple and its software. (Photo by Ed Crabtree.)*

groups are scanned first. When you select the desired group, the cursor will then scan the individual letters or symbols within that group; they are arranged in such a fashion that the most-used letters are easiest (that is, fastest) to reach (see table 1). This routine uses the screen without altering the contents of the screen, and can be used in a transparent fashion with any screen-display program, including those programs that use the graphics screens.

When *step scanning* is selected, all input is controlled through a single switch, as in one-switch scanning. When you press the switch, an array of letters appears at the bottom of the screen, but the cursor does not automatically begin scanning. In step scanning, you hit the switch repeatedly to advance the cursor group by group. When you reach the desired group, wait a moment. After a brief delay (the duration is user-selectable), the group will begin flashing. Then you hit the switch repeatedly to ad-

vance, letter by letter, within the group. When you reach the desired character, wait again. After another brief delay, the computer will accept the letter as if it had been typed on the keyboard. (This method is useful for individuals who are unable to handle the precise timing required for the one-switch scanning method.)

Inverse scanning operates in the same manner as one-switch scanning except that you hold the switch down to scan and release it to select a group or item.

In the *Morse code 1* mode, you press a single switch to send short or long signals ("dits" and "dahs") to the computer. International Morse code or any other code can be used. In addition, all other signals available from the keyboard are also supported, including Repeat and Reset (see table 2).

With *Morse code 2*, two switches are used to form an automatic keyer. One switch sends dits, and the other sends dahs. If either switch is held down, it will send out a series of dits (or dahs) until released. In addition, the software for this mode has a memory buffer and will allow you to get ahead of the computer; thus, if you send "dah dit dah" and hit the dit switch before the first dah is finished, the firmware card will still accept the input.

In the *assisted-keyboard* mode, two auxiliary switches are used for the Shift and Control functions. If you hit the auxiliary Control switch once, the next character will be a control character, but following keystrokes will be unaffected. However, if you hit the auxiliary Control switch twice, the system will lock in the Control mode, and all subsequent key presses will be sent as Control keys until the auxiliary Control switch is activated a third time. The auxiliary Shift switch operates in the same fashion. These switches allow a one-finger typist or someone using a headstick to type all shift and control codes.

A special mode is also provided that allows the Repeat function. To repeat a character, first type the character on the keyboard. Then activate the auxiliary Shift switch, followed by the auxiliary Control switch. As long as you hold down the auxiliary Control switch, the last character typed will repeat. (Activating the Control switch first followed by the Shift switch will result in a shifted control character,

Array	Contents	Special Meanings
Alphabet	R‹#.+ EOHWY TIRUP ANLBK SMFVQ DCXJZ G.!?	R carriage return ‹ backspace # call numbers array . call punctuation array + repeats last character
Numbers	R‹A. 1234 567 890+ *-/=	R carriage return ‹ backspace A call alphabet array . call punctuation array * multiplication symbol
Punctuation	.,?! #"$% '()* /^:_ +;@/ -= REC	R reset E escape C control

Table 1: *Speed-oriented grouping. To maximize the user's speed, the letters are grouped so that the most-used letters take the least time to reach. Spaces can be generated by stopping at any space in the array. Numbers and special characters are accessed through special scanning lines called up from the main scan line using the "#" and "." characters.*

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International Morse Code			
A	.-	W	.--
B	-...	X	-..-
C	-.-.	Y	-.--
D	-..	Z	--..
E	.	1	.----
F	..-.	2	..---
G	--.	3	...--
H	....	4	....-
I	..	5	.....
J	.---	6	-....
K	-.-	7	--...
L	.-..	8	---..
M	--	9	----.
N	-.	0	-----
O	---	. (period)	.-.-.-
P	.--.	; (semicolon)	-.-.-.
Q	--.-	: (colon)	---...
R	.-.	, (comma)	--..--
S	...	? (question mark)	..--..
T	-	' (apostrophe)	.----.
U	..-	- (hyphen)	-....-
V	...-	/ (fraction bar)	-..-.

Additional Codes	
space bar	..--
backspace	----
carriage return	.-.-
escape (OE)	---.
control (KS)	-.-...
right arrow (UU)	..-..-
repeat (HM)	....--
! (exclamation point)	.-..-
$ (dollar sign)	.-.-.
* (asterisk)	...-.
+ (plus sign)	.-...
= (equals sign)	-...-
" (quotation marks)	.-.--
((open parenthesis)	..--.
) (close parenthesis)	..-.-
((ampersand)	-.-..
# (number or pounds)	--.-.
% (percent)	---.-
I (exponent)	......
@ (at)	.---.
< (less than)	-.--.
> (more than)	-.---

Table 2: *Signals for the Morse-code input routine. The Morse-code input routine uses standard International Morse code and a number of additional codes to allow full access to the Apple II. (Adapted from "EMG Activated Spatial Morse Code General Purpose Communication Device" by Carl B. Friedlander and Morteza Rahimi. Proceedings of the IEEE Conference on Frontiers of Engineering in Health Care, Denver, Colorado, October 6–7, 1979; page 298.)*

where that is required.)

When the *parallel* mode is selected, the adaptive-firmware card acts as a straight keyboard emulator. Any parallel ASCII (American Standard Code for Information Interchange) fed to the firmware card through a parallel port will be entered into the computer as if it had been typed on the keyboard.

In the *serial* mode, the firmware card again acts as straight keyboard emulator, accepting serial ASCII data. Any serial ASCII fed to the firmware card will be entered into the computer as if it had been typed on the keyboard. The firmware card will support data rates of 110, 150, 300, 600, and 1200 bps (bits per second). Note that, because a DB25 connector is used for several things, the standard RS-232C pin assignments are not used.

In the *expanded-keyboard* mode, the card will support any 8- by 15-switch matrix.

Special Options

The options available with the firmware card include the *slowdown* option, which allows any program being executed on the computer to be slowed down for use by individuals having slower reaction times. This is accomplished by interrupting the program and inserting delay loops. Because these interruptions are actually triggered by the structure of the program itself, the effect of the slowdown value (which can be from 0 to 255) varies from program to program. Experimentation with individual progams will determine the best value for the given individual and program. (The default value is 0.)

The *paddle* option allows you to use a single switch instead of a paddle to play games that use game paddle 1. When selecting a paddle mode, you indicate a parameter that tells the program which of seven paddle

Mode	User Switch 1	User Switch 2	User Switch 3	User Switch 4
1	activates button 1	moves paddle 1 left and right		
2	activates button 1, moves paddle 1 left and right			
3	activates button 1	moves paddle 1 right only	moves paddle 1 left only	
4	activates button 1, moves paddle 1 left only	moves paddle 1 right only		
5	activates button 1, moves paddle 1 right only	moves paddle 1 left only	moves paddle 2 down only	moves paddle 2 up only
6	activates button 1	moves paddles 1 and 2 right, left, up, and down		
7	activates button 1, moves paddles 1 and 2 right, left, up and down			

Table 3: *Paddle modes. In addition to providing an "alternate keyboard" to the Apple, the firmware card also lets you control game-paddle programs using input switches instead of paddles (and the buttons associated with the paddles). Various paddle modes are available that allow you to move the cursor back and forth on the screen using only the input switches. The table shows how paddle movement is controlled by different numbers of input switches in the different modes. You select the mode that best matches the number of switches you wish to control and the paddle requirements of the game or program you will be using.*

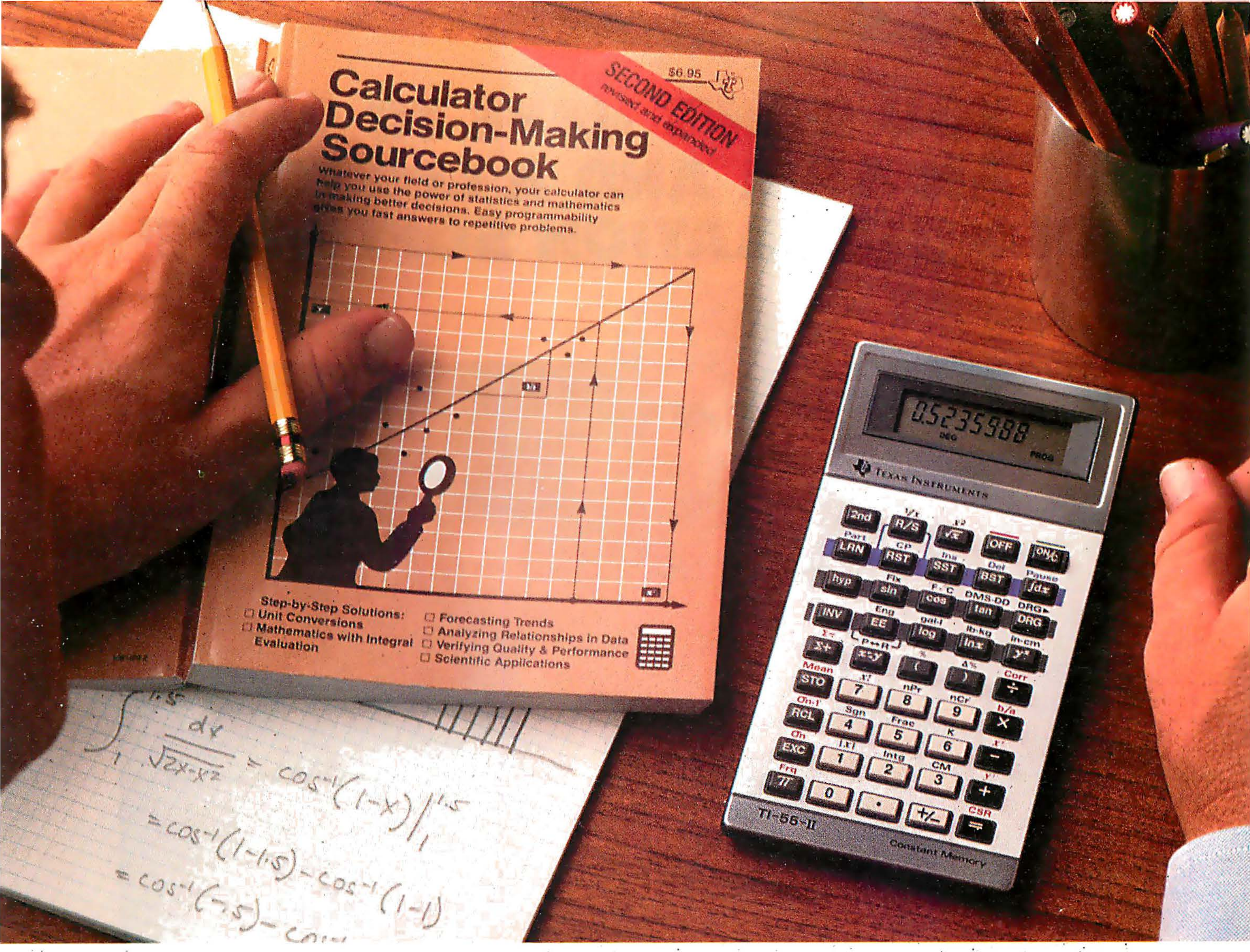
modes should be used. (See table 3 for a summary of the paddle modes.)

In modes where one switch controls movement in two directions, holding the switch down will cause the cursor to move in one direction until the switch is released. Activating the switch again will cause the cursor to move in the opposite direction.

In modes where one switch controls movement in four directions, the routine scans through the instructions for each of the different movement directions until you hold down the switch. The routine will then carry out cursor movement according to the instruction it was on when you pressed the switch; movement continues in this direction until the switch is released. The routine then returns to scanning around the four possible directions until you press the switch again. Thus you have the option of moving the cursor up, down, right, or left.

Seven other paddle modes are available that are exactly the same as modes 1 through 7, as far as the user is concerned, but they use a different software technique to simulate the game paddles. This allows the firmware card to be used with a greater variety of games, which use different game-paddle reading techniques.

Other game-paddle control options



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Circle 235 on inquiry card.

may be developed. The ones above are designed to give different types of individuals using different numbers of switches maximum control of various programs.

The *paddle speed* option lets you adjust the movement speed in the game-paddle emulation routines. The speed set is equal to the number that the paddle count will be incremented (or decremented) each time the program checks for the paddle position (while the user switch is closed). The actual rate of cursor movement for any given setting will vary depending on the software being run. (Paddle speed and mode should be set before entering a game, as access to the "keyboard" input routines is restricted during game play.)

The *stop-time* option prevents your being trapped in a game-playing mode, unable to get back to the keyboard or standard input mode. Under this option, you set a stop-time delay before entering the game-playing mode. When you want to get out of the game-playing mode, simply leave the switches inactive for the appropriate length of time, and you will automatically be returned to your special input mode.

Technical Description

The goal in designing the adaptive-firmware card was to develop a relatively inexpensive interface that would transform the Apple II from just a computer with a keyboard into a computer with a keyboard, a scanner, a Morse-code translator, and more. Such a peripheral would either require its own microprocessor or would somehow have to steal time from the Apple for the translation tasks; thus the two approaches that suggest themselves involve either a card containing a separate microprocessor or an interrupt-driven system.

The former would have the advantage of absolute transparency. It would not, however, provide immediate access to the Apple II's memory. A separate processor could gain access to the Apple's RAM (random-access, read/write memory) by means of DMA (direct memory access). This, however, would mean losing the simplicity of transparency, which was the original attraction of the separate-microprocessor approach. Either way, a number of problems would need to be overcome in order to provide access to all the necessary portions of the Apple without interfering with any program the computer might be running. Also, the separate microprocessor would solve each of a set of problems (which will be discussed in the following paragraphs) in essentially the same way as the interrupt-driven version but would incur the additional expense of the second microprocessor. Therefore, the interrupt approach was used. (The final design is shown in figure 1.)

Apple II Interrupts

The Apple II has two different types of interrupts: the IRQ (mask-

Text continued on page 299

Number	Type	+5V	GND	Number	Type	+5V	GND
				IC6	74LS30	14	7
				IC7	MWS5114	18	9
IC1	74LS244	20	10	IC8	MWS5114	18	9
IC2	74LS374	20	10	IC9	TBP28L22N	20	10
IC3	74LS244	20	10	IC10	74LS74	14	7
IC4	74LS374	20	10	IC11	7407	14	7
IC5	2732	24	12	IC12	74LS21	14	7

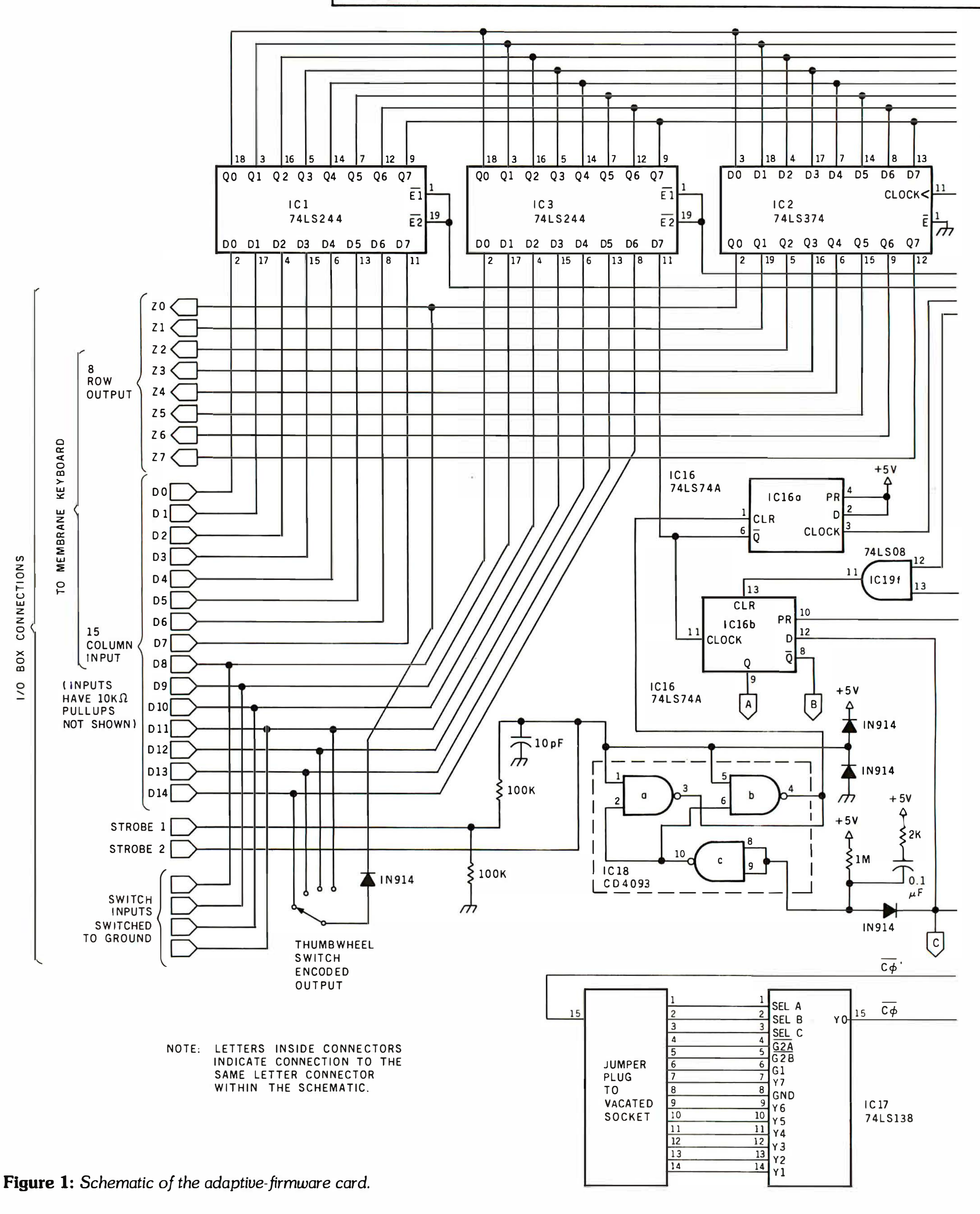
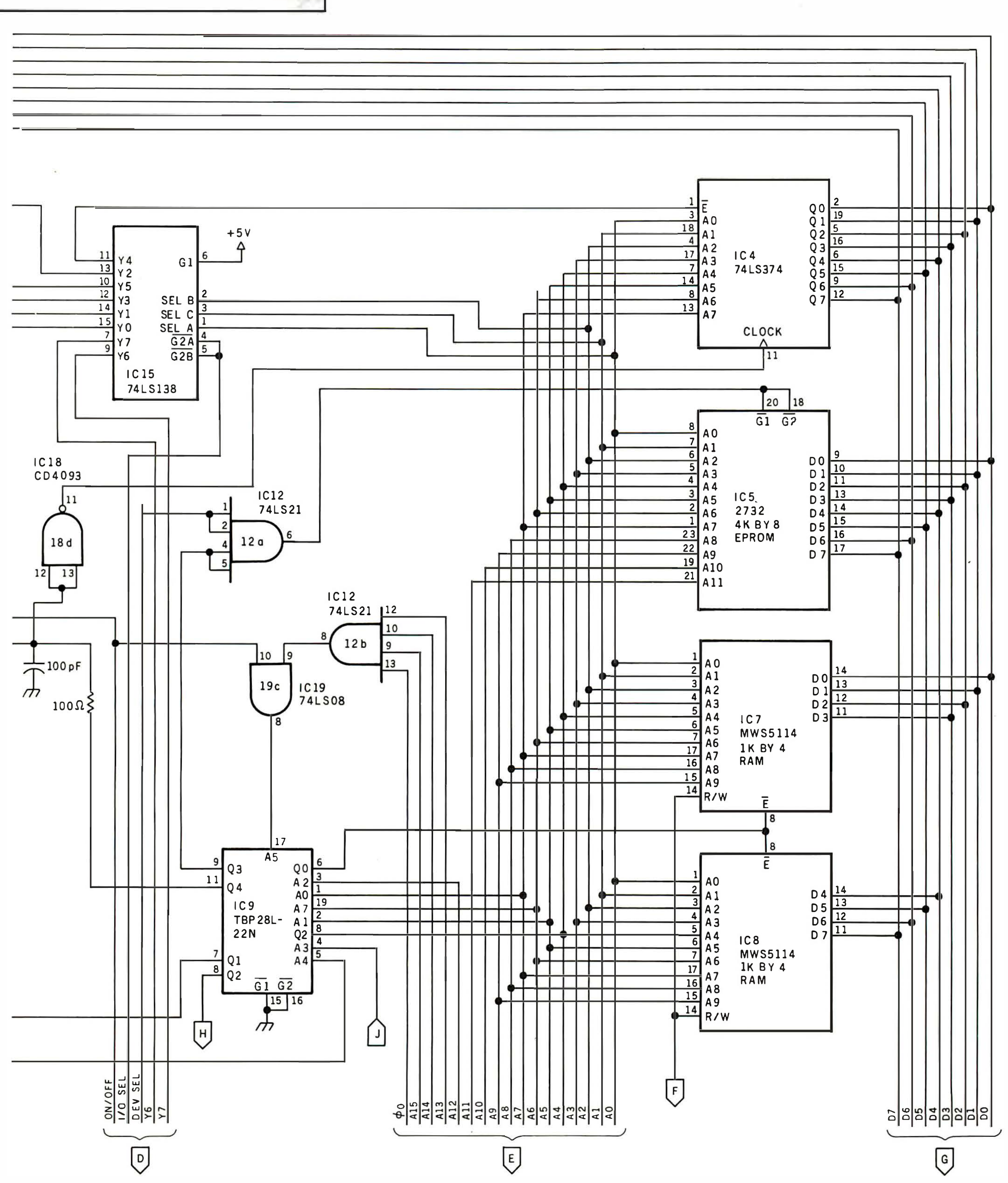


Figure 1: *Schematic of the adaptive-firmware card.*

IC13	74LS05	14	7
IC14	74LS05	14	7
IC15	74LS138	16	8
IC16	74LS74	14	7
IC17	74LS138	16	8
IC18	CD4093	14	7
IC19	74LS08	14	7



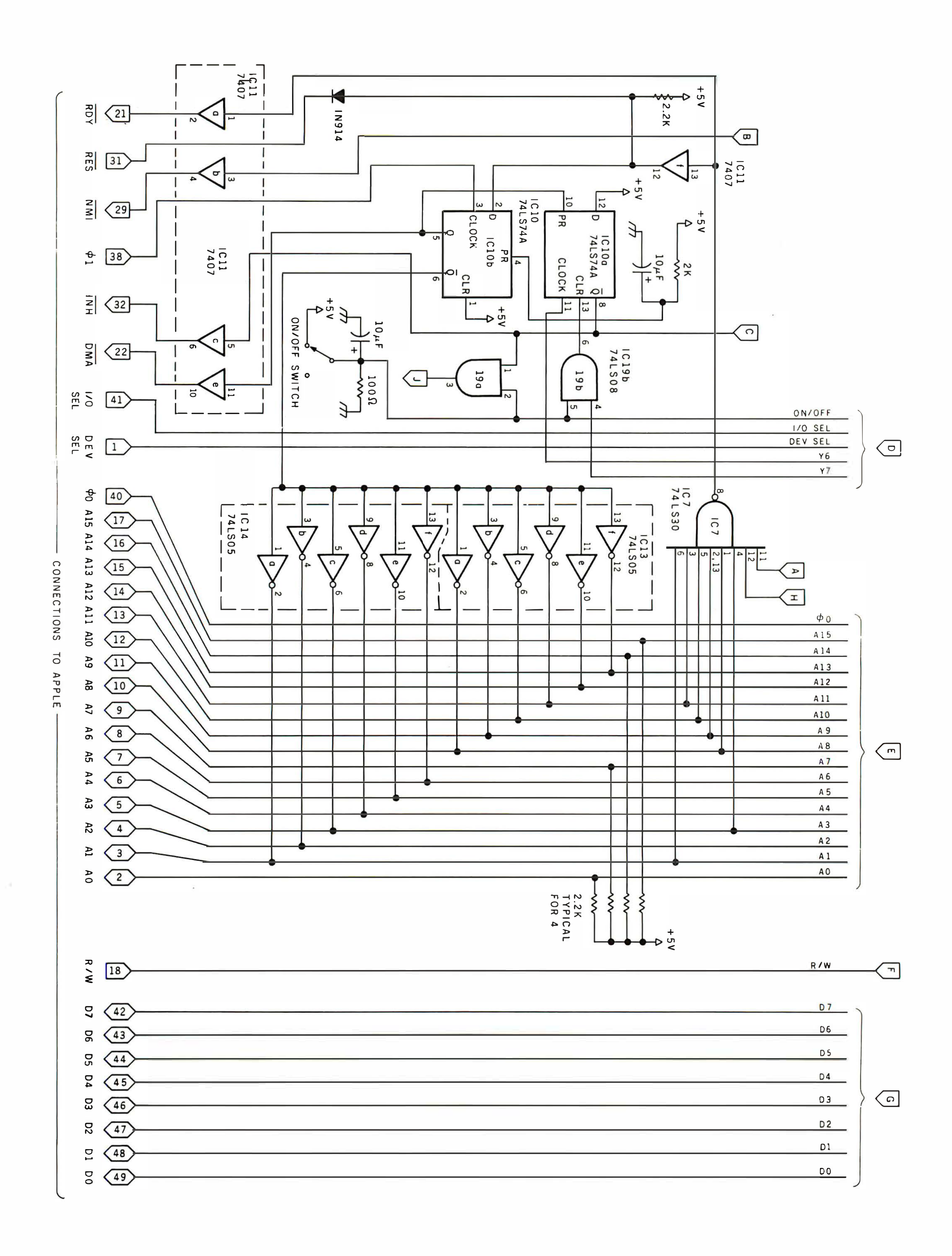


Figure 1: *Schematic of the adaptive-firmware card, continued.*



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Circle 328 on inquiry card.

Text continued from page 291:
able interrupt request), and the NMI (nonmaskable interrupt). When one of these occurs, the 6502 microprocessor vectors to the address at the top of ROM (read-only memory)—for IRQ, the two bytes starting at hexadecimal FFFE; for NMI, the two bytes starting at hexadecimal FFFA—to obtain the addresses in memory that, in turn, hold the address of the user routine that handles the interrupt. Programs using interrupts ordinarily use IRQ because this eliminates the danger of interrupting a disk operation. Because we have no control over the software that might be running, we can't trust that any vectors we set in memory will stay, or even that the interrupt-enable status will not be changed. This means that the NMI must be used rather than the IRQ and that we must gain control over the interrupt-service routine before control is transferred to the soft vectors.

To accomplish the latter, we must have a way of substituting our own ROM for both the Apple's motherboard ROM and any language-card (or firmware-card) ROM that may be in use at the time. This is accomplished by using the INH (inhibit) line (available on the peripheral-card bus) to disable the motherboard ROM and by placing address hexadecimal C081 on the address bus momentarily, which (by convention) turns off the language card in slot 0.

Swapping ROMs

After the NMI line goes low, the Apple's 6502 will execute one more instruction before servicing the interrupt. Since this instruction may be in ROM, we can't substitute our ROM for the Apple's until the interrupt is actually beng serviced.

The adaptive-firmware board waits until the address hexadecimal FFFA appears on the address bus, indicating that the first byte of the NMI vector is being fetched. Only at that time is the adaptive-firmware board activated and the competing ROM disabled. The RDY (ready) and DMA lines are used to halt the microprocessor while this is happening so that the first byte of the NMI vector is actual-

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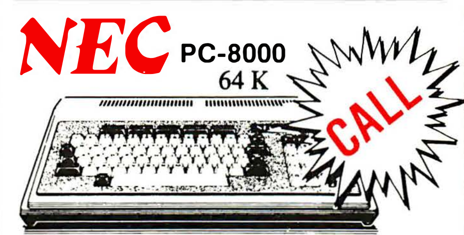
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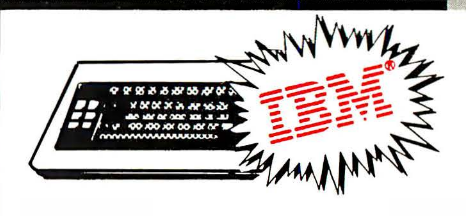
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ly obtained from our ROM on the firmware card. (Although it sounds complex, the process is implemented quite simply in hardware with a few integrated circuits.) A similar approch gives us control over the Reset vector.

Note that this use of the interrupt makes the card potentially transparent to all other programs using interrupts. As presently implemented, however, the card pulls the NMI line low and keeps it low until after the interrupt-service routine is finished. Another peripheral using the NMI in the same way would be incompatible. This problem could be solved by triggering the NMI with a pulse instead of a constant level.

Reversing the Swap

When returning control to the main program after NMI service is completed, a program must reside in ROM that will remain accessible after the card is turned off so that the ROM swap can be reversed. This is easily done by making one page of the ROM accessible at the addresses alloted to slot 7 (beginning at hexadecimal C700) by the Apple II's architecture.

Soft Switches

Depending on the program running on the computer at the time, it may be necessary for the adaptive-firmware card to turn off the language card or to make use of the video display, which may involve switching from full-screen graphics to mixed text and graphics. Both of these operations involve the toggling of "soft switches" (programmable switches) in the Apple.

For the firmware card to remain transparent, it is important that everything be put back exactly as it was before the interrupt occurred. To do this, however, it is necessary to know the status of everything prior to interrupting the program. Unfortunately, many of the soft switches in the Apple cannot be read. They are actually hardware flip-flops set one way or the other by software's accessing particular addresses. For example, if the address hexadecimal C050 is accessed with a read or a write, the Apple goes into graphics mode. Conversely, accessing hexadecimal address C051 causes the Apple to go into text mode.

Similarly, the status of the expansion RAM card is determined by soft switches. In fact, pairs of address references may be used to establish the status of such a card. Thus, some method must be found for reading these unreadable switches.

Rather than try to read the hardware outputs of the flip-flops, the firmware card monitors the address bus continually and makes a note of the appearance of any address that falls into the category of soft switch. One way to do this would be to duplicate on the board the hardware representing those switches, but to do so in such a way that the duplicates could be read by the firmware card.

A better approach is to use the interrupt. Enough of each address on the bus is decoded to determine

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whether the current address is a soft-switch reference. If it is, the lower byte of the address is latched and used to generate an interrupt. The interrupt-service routine then examines the latch to determine the identity of the soft switch and saves the information in memory on the firmware board. This approach allows a much greater number of soft switches to be monitored and at the same time suggests a unique way of generating the interrupts that relate to the main business of the card, as discussed below in Noticing Input.

Split Addresses

Because the 6502 always executes one more instruction before responding to an interrupt, when two critical address references occur together it is possible that one of them would be missed. This could be solved in hardware by using a pipeline, but that complicates the hardware somewhat.

In order to keep the hardware simple and streamline the software service of the interrupts, the firmware card checks in software for double-address references when this seems possible. Admittedly, this is not a foolproof approach—routines could be written to fool the card—however, the probability of such exceptions seems quite small.

Noticing Input

Given that the firmware card can respond reliably and transparently to requests for input, what is the best way to generate those requests? One method would be to have the card generate the interrupts whenever you activate a switch. Unfortunately, if the computer happens to be writing to disk when you activate the switch, data will be lost.

By including the address hexadecimal C000 (the keyboard data-input address) among the soft-switch addresses that produce interrupts, the computer itself will generate the interrupts whenever it checks for input from the keyboard. Then any check of the keyboard by the main program will turn on the adaptive-firmware board and let it check the special source of input, such as the user

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switch. This has the net effect of inserting a few lines of a special translation program (from the firmware card) into the input loop used by the main program.

With this arrangement, the switch input may be monitored in an effectively continuous fashion, or at least as continuously as the keyboard is monitored by the main program. For an input-loop cycle less than a millisecond, the difference between this approach and the switch-generated approach is not likely to be perceived by most users. Most important, this approach eliminates the need to worry about interrupting the program during disk accesses.

Separating Work from Play

You will sometimes want to use the input switches to simulate keyboard input (which causes the input algorithms to be triggered), while at other times you will need the switches for game playing. How can the firmware card know whether to treat the switch activation as a keystroke (which would activate an input routine) or as a game-switch activation (which is just passed through to the game I/O address)?

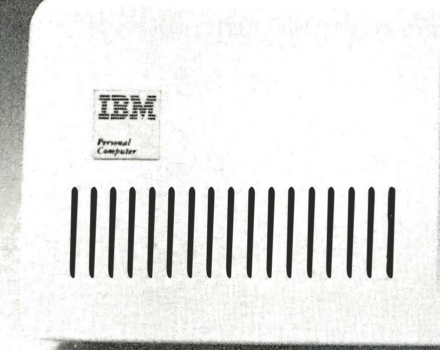
The solution is to add the switch-read addresses, such as hexadecimal C061, to the set of addresses which generate interrupts and enable the card. The firmware card then checks to see what address reference it was that enabled it. If it was enabled by a call to the game switches, the user switch is treated as a game input. If the firmware card finds it is being polled for input from the keyboard, it will activate the appropriate input routine for the user. Thus the card automatically switches back and forth between keyboard and game-playing modes as required by the programs.

Even programs that do not call for any use of the keyboard, however, may address the keyboard location. For example, the BASIC interpreter checks the keyboard with nearly every command to see if a control C has been pressed.

Because the BASIC interpreter can access the keyboard many times between accesses to the game paddles (once for most of the instructions it executes) the firmware card requires 256 consecutive accesses to the keyboard without an access to the game switch or paddle before it will leave the game-playing mode. If the computer program is checking for input from the keyboard, this occurs rapidly; if it is checking only for control C, the game-mode dropout will rarely happen.

If the above technique is used to defeat calls for control C, how would you ever be able to get out of a paddle-based program that was designed to use control C as its exit? The firmware card has an automatic game-mode dropout timer built in. If you don't hit the switch for a certain interval (determined by the stop-time option), the card automatically drops out of the game mode.

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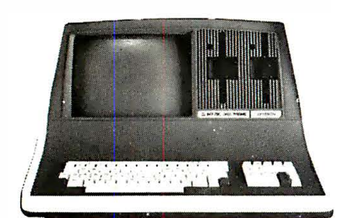
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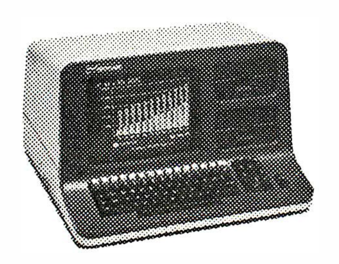
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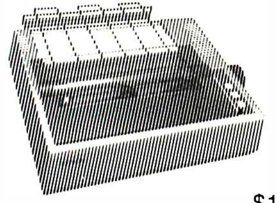


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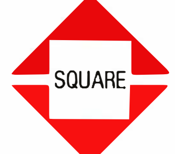
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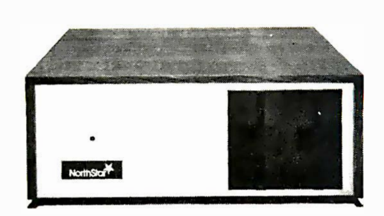
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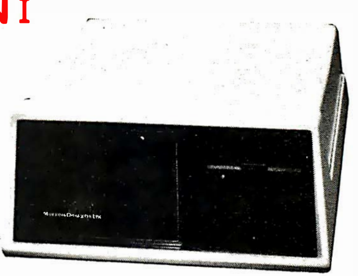
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Emulating the Keyboard

For the entire firmware card to work effectively, it is necessary that it be able to make the computer think that its output is actually coming from the keyboard itself. The most straightforward approach, which is characteristic of most other emulator cards, is to disconnect the keyboard from the main computer and plug the emulator card directly into the keyboard plug on the Apple II motherboard. In order to allow the keyboard to work under this scheme, the keyboard would be plugged into the firmware card. However, this approach requires that the bottom of the computer be removed to provide access to the connectors. Installing the card in this manner is a rather difficult and time-consuming procedure.

An alternate approach is to tap into the I/O decoding by removing one of the decoder ICs and substituting a jumper to the firmware card. The function of the missing device can then be performed selectively by the firmware card. When appropriate, a signal that would ordinarily enable some element of the I/O section of the Apple may be diverted to active memory on the firmware card. In particular, we can arrange to have location hexadecimal C000 decode an address in memory on the firmware card; that is, when the computer tries to read the keyboard, it in fact reads whatever is placed into that location on the firmware card.

This offers a few advantages. First, this arrangement makes installation of the firmware card much easier because the bottom of the computer need not be removed. Second, if it is designed so that the rearrangement of the decoding occurs only when the card is turned off, the keyboard latch and strobe arrangement will be left intact and will function in the normal fashion when the card is turned on. (This allows the card to directly read the keyboard and pass any keyboard input through as well.) Third, this technique allows the firmware card to intercept references to the game-paddle ports, thus allowing the card to do game-paddle emulation.

Paddle Emulation

If we want to allow the user control over the paddle input, some mechanism must be provided to simulate the game paddle. The most straightforward method would be to install a variable resistor in the game slot that could be controlled by the firmware card, but this approach is fairly hardware-intensive. By carrying the substitution of memory for I/O one step further, however, it is possible to gain software control of the values obtained when the game paddles are read.

The Apple's 100-kΩ potentiometer inputs are read by means of timers. In normal operation, the position of the game paddle is read in the following fashion: the X register is loaded with the paddle number; the Y register is used as a counter. The process begins by setting register Y to 0. The NE555 timer is then triggered by a reference to address hexadecimal C070. The processor then goes into a loop, incrementing Y and checking address hexadecimal C063 − X (where X is the paddle number). When the timer runs out, it clears the most significant bit of hexadecimal address C063+X. When this is detected by the loop, the program exits the loop and uses the value of the Y register as the paddle value.

With the firmware card, there are two ways to program the game-paddle value that is read by a program running on the computer. The first method (used by paddle modes 8 through 15) begins by disabling the decoding so that each time the computer addresses hexadecimal C063+X it gets an address in the memory on the firmware card instead of checking the actual hardware switch. The firmware card simply increments one of its own counters and then passes control back to the paddle timing loop.

After the firmware card has been accessed the desired number of times (i.e., the value in the Y register is equal to the desired value), the most significant bit in memory location hexadecimal C063+X (in the firmware-card memory) is set to 0,

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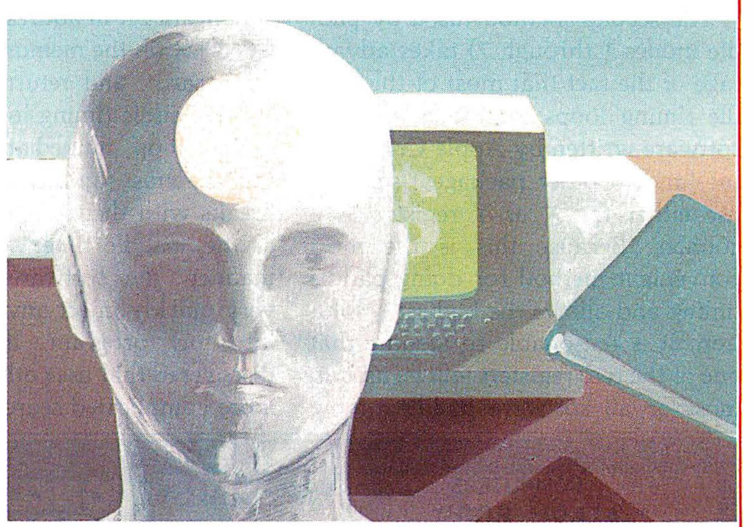
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and control is again returned to the paddle timing loop. The loop detects the most significant bit (thinking that it is seeing the timer flag) and exits from its loop, carrying with it the value for Y that the firmware card wants it to have. This approach has the advantage that it will work no matter who writes the timing loop and what registers are used for counters. It has the disadvantage, however, that it can actually slow the program down by interjecting additional instructions into the otherwise very tight timing loop.

The second method (used by paddle modes 1 through 7) takes advantage of the fact that most of the paddle timing loops examined (both in software written by Apple Computer Inc. and in other packages) seem to use either the X or Y register as a counter. Because this is the most convenient method for doing paddle timing and allows the highest resolution, it is reasonable to assume that one of the two registers will be used in most or all software paddle timing loops.

Based on this assumption, the firmware card immediately checks the values of the X and Y registers when address hexadecimal C070 is first accessed. It then returns control to the loop and allows it to complete one cycle. When the loop accesses address hexadecimal C063+X, the firmware card is again activated. It then checks registers X and Y to see which of the two registers has changed. The program assumes that this is a counter and then loads the desired paddle value into that register, sets the most significant bit in address hexadecimal C063+X (in the memory on the firmware card), and returns control the Apple paddle timing loop.

The loop immediately discovers that the most significant bit is set and breaks with the value in the register as the "paddle timer value." In this manner, the software routine can very quickly inject any paddle value into any program. If software is discovered that uses other registers, a more complicated search routine can be used to find the proper register to "stuff" (store) with the desired paddle timer value. The end result is that individuals using only a single switch or other alternative input techniques can control paddle movement, through the firmware card, for games, drawing routines, and other software applications.

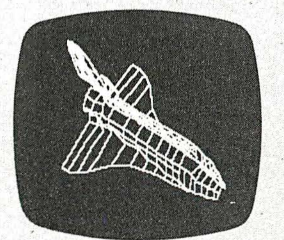
Where Is the Top of Memory?

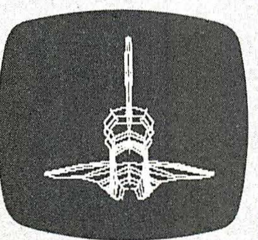
A drawback of the I/O RAM approach is that the address hexadecimal C000 becomes an element of RAM, which could fool an operating system trying to find the top of memory. This does not happen with DOS, but it does happen with Integer BASIC in ROM, if that language is started with control B. The solution in this case is to specify HIMEM. The problem doesn't arise, however, if the disk system is used.

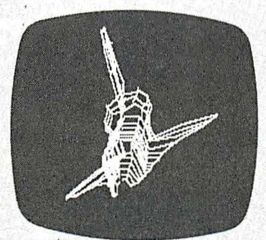
Cassettes and Interrupts

The cassette-input address hexa-

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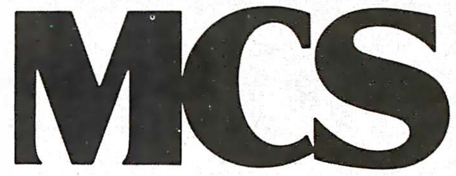
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decimal C060 is one of the addresses that would generate an interrupt. Because the cassette-input routine is a critical timing loop, interrupts make the adaptive-firmware card incompatible with the use of cassettes; therefore, don't use the card in a cassette-based system. The problem doesn't exist with a disk system.

Serial Processing and the Disk

The current version of the card performs serial processing using the 6502 and a software routine. This generally requires a direct-interrupt capability in order to implement the timing necessary to handle the serial input data. A direct-interrupt capability, however, can interfere with disk activity and could be catastrophic if it occurred during a disk-write routine.

A flag is provided, with the serial-input routine, that is set to READY each time the card is enabled and is set to BUSY whenever the program exits from the card. As a result, input is only allowed to the card when the card is active and the disk, therefore, is not. This still leaves a slight possibility that serial-input data could come in immediately after the flag is set to READY and the card is shutting itself down. A direct interrupt that would reenable the card at this point would cause no problem because the card would barely have been deactivated, and there wouldn't be sufficient time to get into a disk-read cycle.

Some Aids Don't Have BUSY

Some serial-output aids do not have BUSY lines and thus would not heed the BUSY signal. This would lead to the aids' interrupting the computer at random, possibly during disk-read cycles. To avoid this situation, the card generates a second signal that totally closes down the interrupt capability of the serial line $\frac{1}{10}$ second after the card is disabled. This is long enough to allow any close-following serial input to be picked up and processed (by enabling reading of the firmware card) but not long enough to allow the computer to get itself to the point of writing to disk.

Conclusions

With a little finagling, an adaptive-firmware card can be developed at low cost that can provide essentially transparent control of a microcomputer while offering a wide range of input algorithms to accommodate disabled individuals with varying physical abilities. In order to achieve this result, however, it is necessary to take advantage of traits unique to the microcomputer. As a result very few, if any, of the specifics of the board for the Apple II would be transportable to other systems. The system, by its very nature, is also not fully transparent.

However, for those individuals who have Apple II microcomputers and who want access to standard software progams, using one of the input techniques supported by the adaptive-firmware card, the card can provide an effective, flexible, and relatively low-cost solution.■

For additional information on the adaptive-firmware card, please send a self-addressed, stamped envelope to:

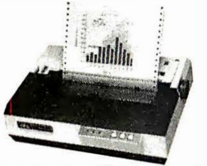
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The original firmware card was developed in conjunction with the Maplewood School Computer Project, Edmonds, Washington. Assistance in the final development and dissemination of the adaptive-firmware card has been provided by the Trace Center's Commercial Facilitation Program, University of Wisconsin, under funds provided by Cerebral Palsy Inc., of Green Bay, Wisconsin, and Grant G008200049 of the National Institute of Handicapped Research, U.S. Department of Education.

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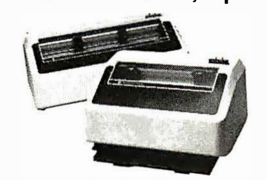
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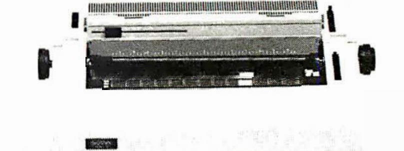
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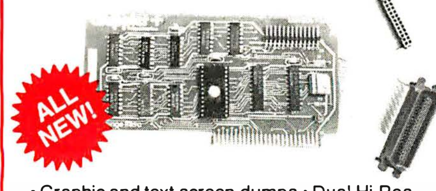
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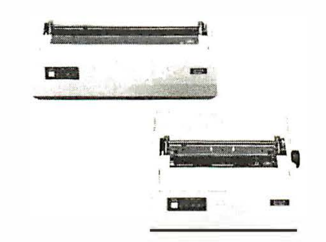


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Letters, Pascal, CB/80, and Cardfile

Jerry gives one man's opinions on a variety of subjects that interest computer users.

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"You're going to regret that silly column," my mad friend used to say. "People won't really read it. They'll *sort of* read it and then send you nasty letters refuting things you didn't say, and they'll be indignant about it, too."

"Come on, you encouraged me to write this column!"

"So I did."

"So what do I do?"

"Give me the letters. I'll help you answer them."

My mad friend was right in his prediction but alas cannot help me with the mail. Fortunately, things aren't as gloomy as he predicted. Some of my mail is reasonable and informative, and a lot more is at least informative. . . .

What, though, do I do with the letter that begins "I thoroughly enjoyed your column of xxx, but have you tried a Frammistan 9 running at 6.7 MHz with the model 3853.4? I've had one for five months and never had a glitch. . . ."?

While I'm grateful for descriptions of systems I haven't access to, I can hardly write about them; by its very nature this column has to concentrate on equipment I have and programs I either use or tried and didn't like. Now I know in a sense this is unfair. In an ideal world I'd have nothing to do but play about with computers and programs and write absolutely unbiased accounts complete with benchmark times and bug reports; but this isn't an ideal world.

There's a limit to the time I can spend bopping about with computer systems, the number of computer systems I can own, and, indeed, the number I can use no matter how I get them. There's a limit to the number of programs I can review and the languages I can learn. These aren't limits I like very much—left to my druthers, I'd spend several hours a day playing with computer systems—but they're pretty absolute. I am primarily a book writer, and every now and then I have to deliver a book. There's no help for it. After that, my copious free time is divided among a number of important—well *I* think they're important—activities. I am, for my sins, an official of the Science Fiction Writers of America; the secretary of the L-5 Society (an outfit you ought to join; send $25 to L-5, 1620 E. Elm, Tucson, AZ 85719, and tell 'em I sent you); chairman of the Citizen's Advisory Council on National Space Policy; member of the Board of the Los Angeles Science Fantasy Society; and hikemaster of my local Boy Scout troop, and if you're wondering how any human being can do all that, so am I after listing it.

If you're wondering why I didn't answer your letter—read on.

Now I'm not looking for pats on the back (in truth I ought to give up one or another of those activities since I can't give all of them the time they deserve), nor can I really excuse my inability to answer all my mail. But as they taught us way back when, there's never an excuse, but there may be an explanation, and if you're wondering why I didn't answer your letter, now you have an explanation.

The upshot is, of course, there are good hardware systems I have never described in this column. Some I never heard of, and even if I had, it's certain I can't buy every system that comes out. Some I have heard of,

with sufficient negative comments so that I've little interest in further investigation—yet in fairness I can hardly pan something I have no personal experience with. The bottom line is I don't at all mind your telling me about your favorite system or program, but do understand that I may never be able to write about it. That's not optimum, but I don't see what I can do. I really am dancing as fast as I can.

Now for specifics.

Drive Along Little Doggie

Have I been too hard on 5¼-inch disk drives? A number of correspondents tell me I have. Some I can ignore, such as the reader who sent the letter accompanied by a catalog of software sold only on 5¼-inch disks—I don't ignore him because of the obvious self-interest, but because both the cover letter and the catalog are illiterate, making me wonder what the program documentation is like. But there are also sane letters. The most rational says, "You do need two disk drives with at least 250K bytes of memory to do much of anything, and three drives are required to run many programs rationally . . . [but] a 5¼-inch [disk] is more convenient than and just as reliable as an 8-inch [disk]. Speed is slightly slower when transferring large files, but the difference is hardly noticeable during normal operator interaction. One 8-inch drive is nice to read the original CP/M disks, but the only real requirement is to pick something that Lifeboat supports. A hard disk is where we are all going anyway, and the basic requirement is to get programs in and data back out."

Let's look at this a chunk at a time. First, one 8-inch drive is silly; there are few power-supply cabinets built for a single 8-inch drive, and if you're going to get one, you might as well get two and be done with it. Incidentally, I still strongly recommend the Qume DT-8s; double-sided and double-density, they store over a megabyte per disk, and with a Compupro controller, they're very fast. My friend Bill Grieb of System Interface Consultants has had good experience with Qume disks in the Integrand S-100 box, a package containing a seven-slot bus and two drives in a box smaller than the one my Cromemco Z-2 occupies without drives. The point is, if you're getting one 8-inch drive, you might as well get two. You just don't save that much money or space.

Second, my correspondent rightly states that you can't get along without top-of-the-line 5¼-inch disks: that is, disks that hold 250K bytes of memory and more, which is to say hold 40 tracks and are double density. Unfortunately, those aren't cheap. They are smaller than 8 inches, which is the only "convenience" I know of; but three of them take up only slightly less room than two DT-8s.

Third, my experience with 5¼-inch reliability is not his. True, I was working with experimental stuff in the Dark Ages (two years ago); thus, I might be wrong. The fact remains that a 5¼-inch disk is nothing more than the inner 40 tracks of an 8-inch system, and the inner tracks are the least reliable.

But to me the fatal flaw is the lack of any standard format in 5¼-inch disks. With 8-inch disks, CP/M is CP/M, and everyone can read each other's data files. Alas, that's not so with small disks.

Now it's true my Godbout system cannot read double-sided double-density disks created by my son's CCS (California Computer Systems), even though both use Qume DT-8 disk drives and, in general, each disk-controller manufacturer has his own double-density format that's unreadable by any other controller. However, nearly all 8-inch systems I know of can read IBM 128 bytes/sector, single-sided single-density disks, meaning that I have access to most of my friends' machines and they to mine. There's no comparable standard with 5¼-inch disks and thus communications are considerably hampered.

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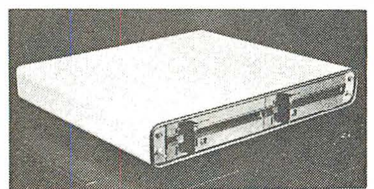
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I agree that we're all headed for hard disks. The clutter here at Chaos Manor (I now face three sets of dual 8-inch disk drives plus two 5¼-inch disk drives plus a hard-disk drive) tempts me sometimes to reduce the size of everything; but I want more software than Lifeboat can supply, and I don't know what format of 5¼-inch disk to buy, so I'll stick with at least one pair of DT-8s, hard disk or not.

Finally, there's the safety factor. You may trust your hard disk, but as far as I'm concerned, my text isn't really safe until it's written onto a disk and the disk is put in a nonmagnetic metal box on the other side of the room. Little disks just don't hold enough text, nor do I have that much confidence in them.

All told, then, I'll stay with the big floppy disks.

M & N s and Are You a Compiler?

I've previously mentioned my Compupro M-Drive, which we've designated as drive "M" and Semidisk, which became drive "N." For the few who don't know, these are two different schemes for fooling your computer into thinking that a big block of memory is a disk drive. I doubt that I've sufficiently praised them. Both Compupro's M-Drive and the Semidisk system work so well that you don't notice them.

The Compupro system is marginally faster than Semidisk's, and the Compupro memory can be used as RAM (random-access read/write memory) for your 8088 when you use your 8085/88 that way; but the system requires a Compupro disk controller and an 8085/88 processor. Meanwhile, Semidisk is plenty fast and can be used with *any* CP/M 2.2 S-100 bus system, no matter what controller and processor are being used. And having them can change the way you do things.

There are times when I am willing to take Pascal and stuff the language into a culvert. There truly are times when I completely agree with my late mad friend, who thought Pascal useful for classroom exercises, particularly in places that didn't have computers for the students to work with, but not much use for practical programming. Lately I've been helping my son Alex and his classmates work on the Workman and Associates' Pascal Introduction Package: they're taking standard programs out of standard textbooks, such as Peter Grogono's *Programming in Pascal* and the Kernighan and Plauger classic *Software Tools in Pascal*, and getting them to run with Digital Research's Pascal/MT+ and Sorcim's Pascal/M compilers. And the job is driving me nuts. Alex and his friends will *earn* every nickel they make.

Pascal really and truly expects the programmer to be a sort of precompiler. Consider error messages like "Error number 6: Illegal symbol (possibly missing ';' on line above)" and "Error number 51: ':=' expected." Pascal/MT+ even shows you precisely where these errors are expected, and usually the compiler is right about the guesses, too.

So why don't the compilers simply *supply the needed symbol*? Especially when they found "=" where they expected ":="? Now it's true that you don't want to depend on compilers to do your thinking for you. You really ought to go correct the program. But I don't see why they can't give you the specific error message, plus say "following assumption implemented," and show you what they did, then continue with the compilation. That way they would catch nearly all the trivial errors in one pass, and then you could go back and correct them all at once rather than having to load the editor, add a semicolon, exit the editor, compile until the next trivial error, etc., ad nauseam.

We have both M and N drives (on the same machine; if you type in "PIP M:=N:*.*", the result is blindingly fast), and thus the cycle isn't so long for us. After all, the disk-access times are pretty short, so we're not waiting for the editor or the compiler to load or the editor to write to disk. I think I would probably have given up on Pascal without them.

It isn't just the trivial errors that make Pascal hard to use. Although the compiler's intolerance for trivial

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mistakes seems to me a mistake, one assumes that study and practice will overcome that. Nor am I certain precisely what is wrong; but here I'm watching students who've been working with Pascal for four years take hours and hours to debug programs copied from a standard textbook recommended by the compiler writer. That's portability?

I suppose I shouldn't complain. Alex expects to make a lot of money off his Pascal lessons. When he first started working on the concept, I wasn't sure it would be worth what Workman said he'd have to charge; but that was before I got involved in helping out: that is, Alex had some exams coming up, so I volunteered to type in a couple of Grogono programs and get them running. They were, after all, simple programs, and all that was needed was to copy them out of a book, to spend an hour or two typing, and perhaps to put in an hour debugging. . . .

Hah! Didn't work that way at all. First, even with Semidisk it took longer than I'd have thought to get rid of all the trivial errors. Then the fun really began. There are more obscure errors and faults in Pascal than you can dream of, even if you spend weeks studying a good introductory text like Grogono's.

For example: "Error number 253: Procedure (or program body) too long. Reduce the size of the procedure and try again."

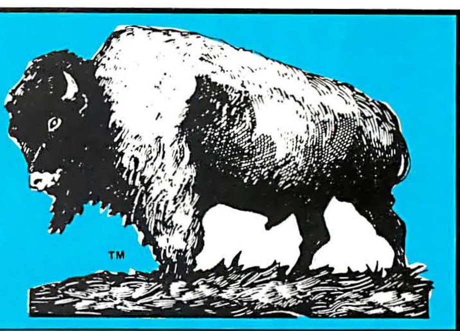
I searched the index in *Programming in Pascal*, Digital Research's Pascal/MT+ documentation, and Sorcim's Pascal/M document. Nary a word about this, or at least none I can find. Programs that will compile in Pascal/MT+ give you error 253 in Pascal/M. You fix that by shortening the program, which you can do by taking a number of messages that are delivered only once and putting them into a procedure (although it's a bit silly to call a subroutine just to read the instruction messages). Of course, the procedure was (trivially) wrong the first couple of times. Then the random-number generator Grogono uses wouldn't work because he uses the integer 65536. Mike Lehman, who wrote Pascal/MT+, told me on the phone simply to change that to 65536.0, thus changing it into a floating-point number; but that doesn't work either, because Pascal will not do implicit type conversion, and we needed the MOD (get the remainder, or modulo) function, and Pascal won't let you do the MOD function unless you're dividing by an integer. . . .

So, we wrote a "get remainder" procedure, only that ran into conflicts of variable types.

Then we tried a different random-number generator and went through the Grogono program to document where and why we changed variables from integers to real numbers, and after about three times as much time and work as I'd expected, that program is done. There are a lot more like that in the package Alex did; and



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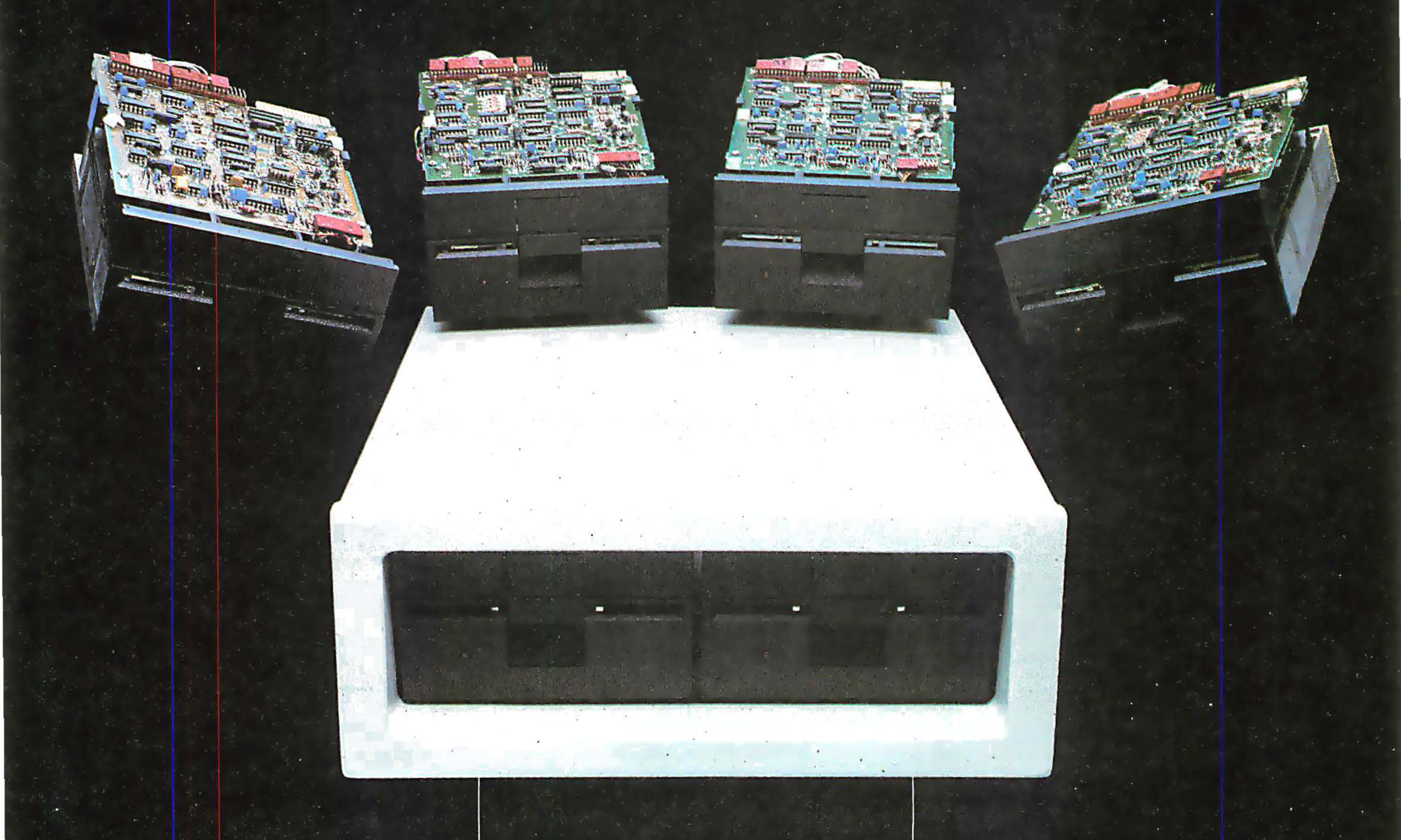
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if you don't know Pascal and intend to learn it, I *strongly* advise you to buy the Workman package (compiler, *Programming in Pascal, Software Tools in Pascal,* and Alex's lesson disk). That way you won't waste so much time with trivial error hunting, and you can get down to the business of playing with those programs, modifying them, and using the more useful ones.

And if your time is at all valuable, get either M-Drive or Semidisk. The slower your floppy disks, the more dramatic the result, but even with fast disks like Qume DT-8s run by a Compupro controller, the time saved adds up fast.

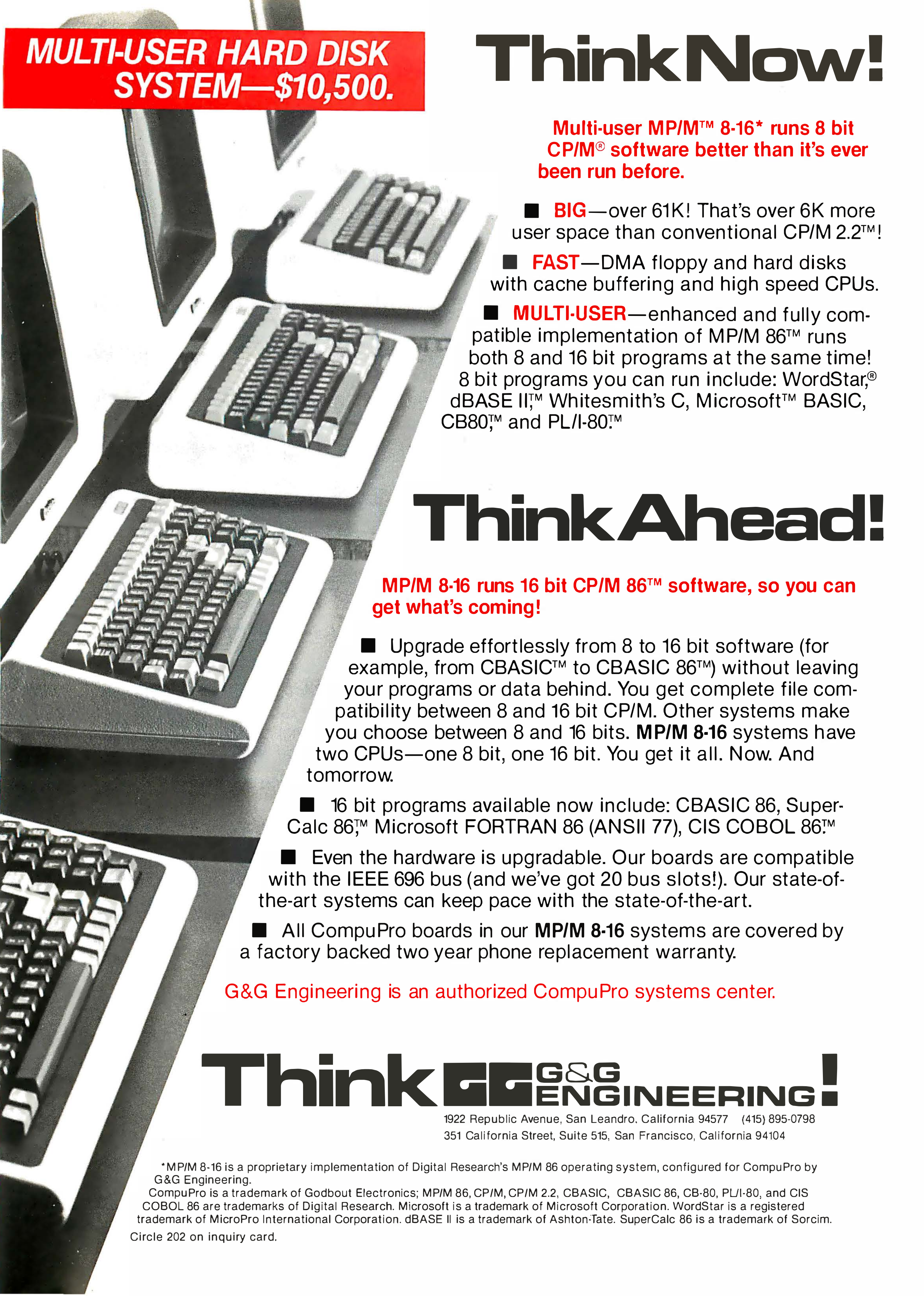
CB/80 Revisited

There is an alternative: Digital Research's CB/80, which is compiled CBASIC. Our tests so far show that CB/80 is pretty comparable to Pascal/MT+ in speed and compactness of code. It's *reasonably* easy to patch in assembly-language subroutines in CB/80, so that you can optimize loops and other things that you use all the time. There's a new version of CB/80 with an improved linker that's supposed to make patching in subroutines even simpler; I'll have it in a couple of weeks, and I can report on it then.

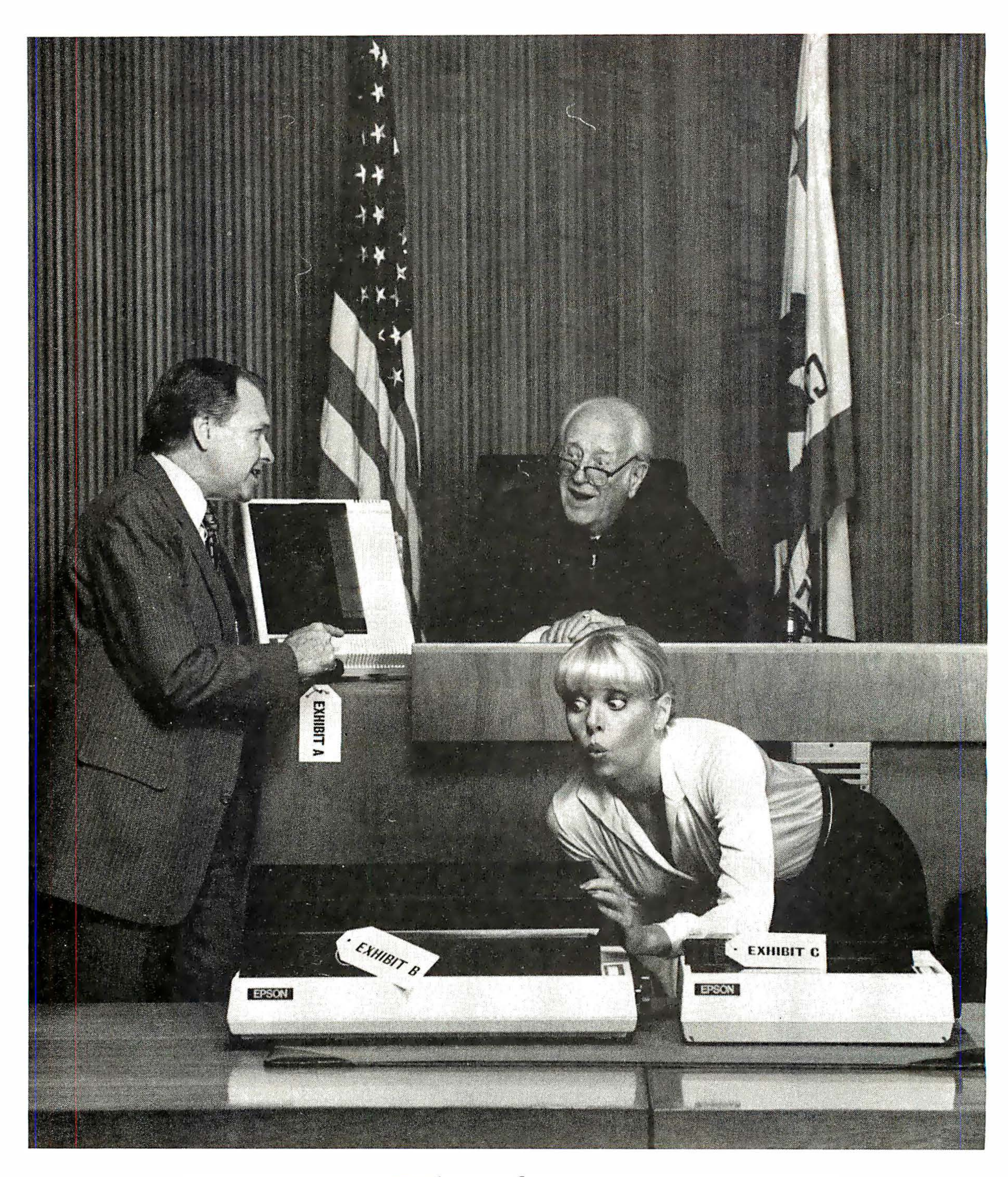
Despite my mad friend's misgivings about all forms of BASIC, CB/80, in my judgment, remains a real competitor to Pascal and PL/I. It won't write code as fast or as compact as C, but then few higher-level languages will, and it's a lot easier to learn than C. I suspect, in fact, that my mad friend would salve his anti-BASIC prejudice by pronouncing that CB/80 isn't "real" BASIC at all but a separate new language.

He'd have a point, too, since CB/80 has few of the inherent defects of BASIC. With CB/80 you can have truly local variables within functions and procedures and call them either by label or by value—that is, you can hand the procedure the actual value of the variable it is to work with, letting it create a variable that's local to the procedure so that whatever it does cannot change the "real" variable out in the main program; or you

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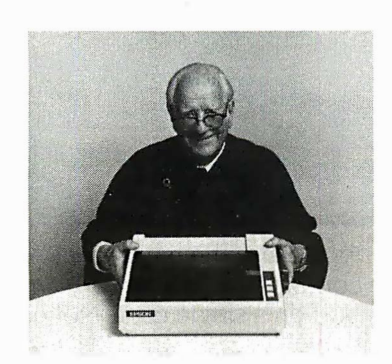
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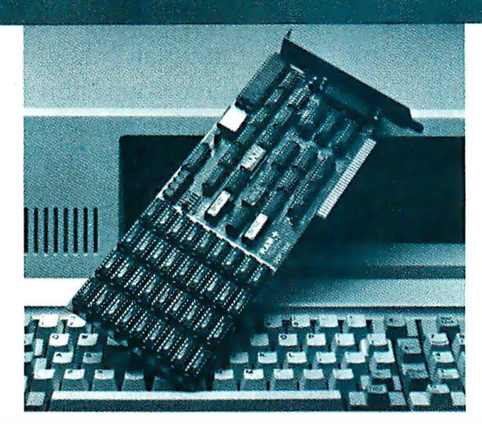
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can write the procedure so that it manipulates global variables and affects everything. True, CB/80 doesn't name its multiline functions *procedures*; but they have all the attributes of a Pascal procedure, can be called by name, and in some ways are easier to use.

The bottom line is I'm still thinking about the language problem. I don't think anyone knows which will be—or *should* be—the microcomputer language of the future. But now that CB/80 is available without unduly restrictive licensing agreements, I wouldn't count it out.

Cardfile

Longtime readers of this column will know that I have no high opinion of the prevailing state of program documentation. There's a reason for that. For example, about a year ago, I received, unsolicited, a program for review. It came with a handsome document and had an intriguing name that made it sound as if it might be very useful. My mad friend Mac Lean claimed it as his next project, and that seemed reasonable, so I let him take it away.

Once I got Cardfile running, I liked it fine.

He returned it the next week.

"Does it work?" I asked.

"I think so."

"You *think* so?"

"Yeah. It seems to work all right. Nifty images come up on the screen, the cursor moves around. . . ."

"Then what's wrong?" I asked.

"I have read the document five times, and I cannot understand what the program *does*."

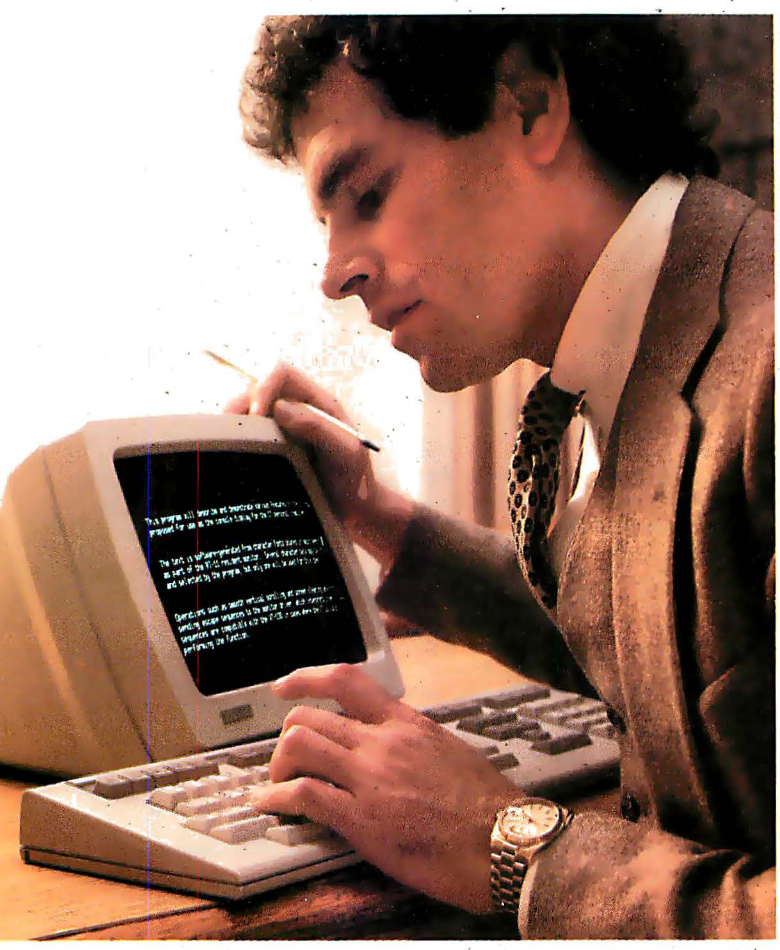
He was right, too. That program now lies under a moldering pile of unreviewed software languishing in a far corner. It may stay there forever.

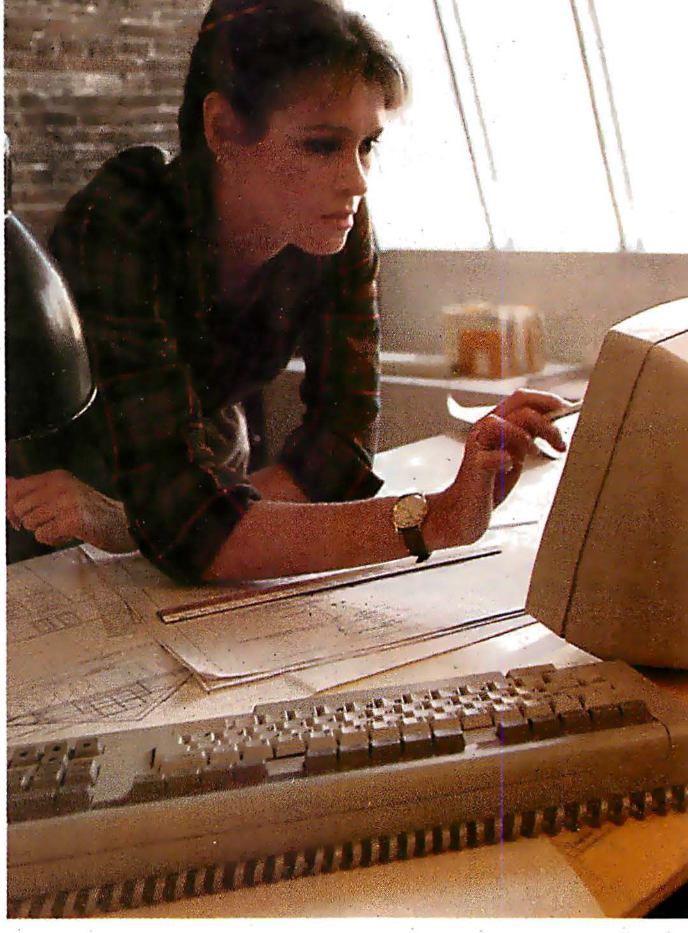
Which brings us to Cardfile, a rather nifty program distributed by Digital Marketing Corporation, whose rather distinctive logo has appeared in a number of computer magazines lately. Digital Marketing seems to have sent me Cardfile and Synopsis, or perhaps I picked them up at the West Coast Computer Faire; if there was a cover letter, I've lost it, so I've no way of knowing where I got it, and yes, this is relevant to the review.

However I acquired them, Cardfile and Synopsis reached the top of the queue; and all my students and associates were working on other projects. From the titles they sounded intriguing. Cardfile, for example, is subtitled File Card Index Program, which sounded useful, and when I got inside, the "Overview" section of the program document informed me that "Cardfile automatically stores, retrieves, and displays information that is typically kept in index card files—summaries of articles and books, notes, recipes, menus, catalogs of books, phonograph records, tapes, etc."

Now that sounds pretty good. Down below it tells me that "Cardfile requires an 8080/8085 or Z80 computer with at least 52K RAM; CP/M 2 or MP/M; and Wordstar, Spell-

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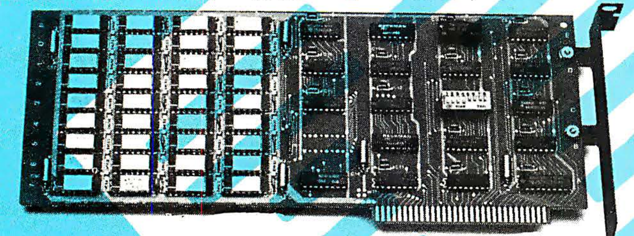
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Cardfile (by Protem Software)		$89
Synopsis (by Protem Software)		$125
Digital Marketing Corporation 2670 Cherry Lane Walnut Creek, CA 94596 (415) 938-2880		
CB/80 (compiler version of CBASIC)		$500
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Compupro Systems	256K	$3100
Oakland Airport, CA 94614-0355 (415) 562-0636		
Pascal Introduction Package		$50
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Pascal/M		$395
Pascal/M-86		$495
Sorcim Corporation 405 Aldo Ave. Santa Clara, CA 95050 (408) 727-7634		
Pascal/MT+	8080, 8085, Z80	$350
Digital Research	8086/8088	$600
Box 579 Pacific Grove, CA 93950 (408) 649-3896		
Semidisk	512K bytes	$1995
Semidisk Systems	1 megabyte	$2995
POB GG	manual only	$10
Beaverton, OR 97075 (503) 642-3100		

Books Reviewed

Programming in Pascal	$15.95
by Peter Grogono Reading, MA: Addison-Wesley Publishing Company, 1980 (rev. ed.)	
Software Tools in Pascal	$15.95
by Brian W. Kernighan and P. J. Plauger Reading, MA: Addison-Wesley Publishing Company, 1981 (617) 944-3700	

binder, Magic Wand, or a similar text editor." Well, I've got an 8085, CP/M 2, and plenty of RAM. I don't have Spellbinder (I've asked, but Lexisoft has never sent a review copy).

I don't have Magic Wand, and therein hangs a tale: when Magic Wand was first developed, the then owners sent me a copy, which I spent far too much time working over. There were about 20 exchanges of letters and a lot of phone calls as I pointed out problems with the editor, especially the disk operations. In general, I ended up putting a lot more time into it than I should have. I did that because I *liked* the product a lot and thought it ought to have the bugs ironed out.

SBA (Small Business Associates) lost control of Magic Wand. The new owners inherited a pile of correspondence from me. When I called one day to ask what was happening, they acknowledged my help in pointing out design flaws and promised me the new and revised copy of Magic Wand "real soon now." Before I got it, Magic Wand was sold to Peachtree. I've written Peachtree four letters and spoken to its representatives at three different computer shows; the company has yet to acknowledge my existence. Now I have a perfectly good editor, and I don't need Magic Wand, but I do confess some curiosity as to how many of my suggestions the company adopted.

Anyway, I don't have Magic Wand. I do have Wordstar, but I don't use it all that much, and in fact, it isn't on the system master for the Compupro 8085/8088. But what the heck, WRITE, the editor I use, has some similarities to Magic Wand in that it marks the ends of lines with nothing and the ends of paragraphs with a carriage return but no linefeed; and the document did say "similar" text editor. Maybe it would work.

But then I began reading the rest of the Cardfile document, and holy catfish! It doesn't tell what it does! There's a set of instructions on how to use it, but they weren't helpful—at least not to me—on what the darned program was going to do.

What it *said* was that after I did some installation, I should use my text editor in a special way to "create a separate document file for each record you wish to enter in the Cardfile index." I could, it said, name the document file anything I want, except that I couldn't use an extension of .Y because the program was going to create *another* file with .Y extension for each one of the files I was about to make.

This sounded like a great way to fill up a disk but about as useful as a chocolate-covered wristwatch.

Furthermore, the instructions told me that "the disk directory for a standard floppy disk holds 64 entries." That's not strictly true for CP/M 2.2, but it did seem to impose some new limits. What good is a card file that, with its index and command programs, can't have more than 25 or so cards in it? Especially since Digital Marketing Corporation's licensing agreement says I'm permitted only two backup copies of the program.

Well, maybe I was reading it all wrong. I certainly seemed to be having trouble understanding the program instructions (and it wasn't that late, either). So to be fair, I ran the program itself.

I began with the installation routine. It comes up with a menu of Wordstar, Spellbinder, or Magic Wand and will not accept any other editor whatever. So much for "similar," but the heck with it. I told it my editor is Magic Wand, then answered the other questions. What you do is give it the name you invoke your editor with (WS, MW, Foo, whatever; in my case, WRITE) and the name you propose to use to make Filecards (WRITEC in my case). Then you go WRITEC, and up comes their prompt first, then WRITE's.

WRITE seemed to be working all right, barring the fact that I couldn't get the disk directory; apparently, Cardfile's shell program, which the company calls an "environment," interferes with WRITE's rather sophisticated directory calls (which show file *size* as well as name). Ah, well. Everything else looked all right. So I proceeded to create some typical cardfile "gubbage," saving each file under a different name but with file extension .GUB, and exited the editor. Sure enough, for each of the .GUB files I'd created, there was a corresponding .Y file.

Then I invoked the Cardfile program itself; lo, it worked fine. First it updated its index, then displayed self-explanatory prompts inviting me to search the card-file index. Simply give

it a key, and it looks until it finds what you need, which it does pretty fast. And when I exited Cardfile, I found all the .Y files had vanished.

Did I need the original .GUB files? One way to find out was to erase them. And, indeed, the information in them was still available. I'd been fooled by the program document's constant references to "updating the index," which implied to me that it only made indexes rather than copying the entire card-file information. Finally, a careful reading of the document told me what I'd missed: Cardfile creates a random-access file whose default name is CF.DAT. All your information is stored in there. CF.DAT need not be on the same disk as the Cardfile program and, indeed, can be renamed anything you like.

Moreover, all of that is stated in the document, and on reading it over now it's all pretty clear; how could I have missed it?

Well, first, prominently up at the top of page 2, the document describes CF.DAT simply as "a sample data file to permit experimenting with CF." This was apparently sufficient to cause me to ignore any further references to CF.DAT; there were only a couple in the opening sections.

Second, after reading the "Overview," I turned to the "Theory of Operation" section. The section is *not* a description of the program at all; it's a description of how the program does a rather small part of what it does. There is no mention of CF.DAT or even of random-access files. By using the rather pretentious "Theory of Operation" as a section title while describing only a small part of the program, the documentation writers made it pretty tough to infer what the program really does.

But once I got Cardfile running, I liked it fine. You can use it about as you'd expect, to make notes and the like. You can print the notes on paper, pull them out into separate disk files (so that they can be read into a document), or simply erase them. It's a bit of a pain to exit your editor and then reenter it when you want to make a note for another time, but the document tells you how to avoid doing that (as a matter of fact, in the infamous "Theory of Operation" section).

I presume that Synopsis works much the same way; a cursory look at the system documentation drove me away, but that was before I mastered Cardfile. Now that I understand what the program does and sort of how it does it, the Synopsis document no longer looks so forbidding. What Synopsis does is let you put four lines at the top of any document you like, then read those four lines into a random-access file called SYN.DAT. It keeps keys to those lines in SYN.KEY and has various search modes. Of course you ought to make the four lines as descriptive as possible.

Synopsis will automatically make the first four lines of a file *comment lines* for your editor (so long as that editor is Wordstar, Spellbinder, or Magic Wand). A comment line is one that will show on the screen but will not be printed. Wordstar uses ".." to introduce a comment line. Spellbinder uses ".r", while Magic Wand uses "\ *". As an aside, I've often wondered why text editors can't use something sensible, like

;. (*. --. {. /*

or preferably *all* of them, as comment line markers. As you may have noticed, the characters ;, (*, --, /*, and { are the "open comment" characters for the 8080 assembler, Pascal, Ada, Pascal again, and C compilers, respectively, and thus will be ignored during assembly or compilation. By allowing the "open comment" character followed immediately by a "." to be the *editor's* comment line marker, you could embed formatting and comment commands into your programs and still compile directly rather than recopy. I've mentioned this to Tony Pietsch, and he's modifying WRITE to work that way.

In addition to the four-line synopses, Synopsis also catalogs the filename and disk name. (You name the disk with a title beginning with a hyphen so that it will be sorted to the top of the file.)

Anyway, I haven't run Synopsis, but I can see how it could be useful, and since it works pretty much the same way Cardfile does, I don't foresee any difficulties with it. It seems to have some similarities to the Ward Christenson Catalog program (public domain) available from Barry Workman or the CP/M User's Group, but it has added features as well. I expect we'll be using Cardfile here. ■

Logo: An Approach to Educating Disabled Children

Action-oriented learning has dramatic benefits.

Sylvia Weir, Susan Jo Russell
and José A. Valente
MIT Logo Group
545 Technology Square
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While a computer is a learning and teaching tool appropriate to many educational settings, it can be much more than that for an educationally disabled child. It makes equal opportunities possible in cases for which conventional educational methods are not feasible or effective. A computer can provide a vehicle for genuine intellectual achievement. For a physically disabled child who has limited access to the world of motion and spatial relationships, for a learning-disabled child who shows a flair for geometric problem solving, and for a nonverbal child who is blocked in establishing communication, developing a facility in using a computer can be regarded as an essential educational experience.

A major potential of the computer in an educational context is its flexibility, which allows a teacher to tailor a learning situation to the specific requirements of a particular child. Nowhere is this more important than with disabled children, where the range of individual variation is very great. Such students present the same challenges to teachers as do nondisabled children and, in addition, have many special problems of their own.

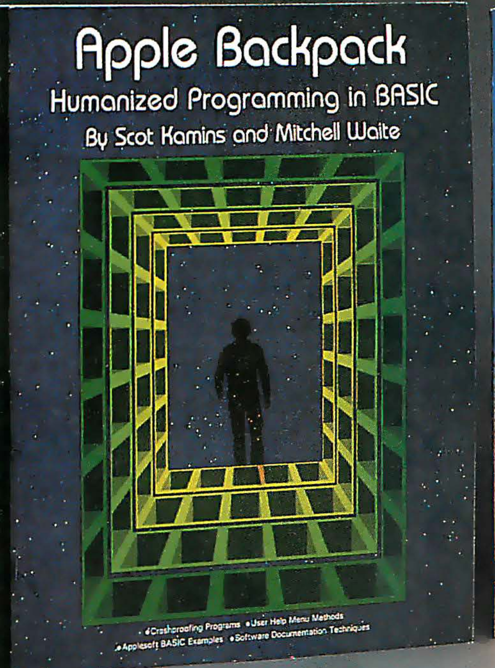
Logo activity emphasizes methods of doing things rather than answers—process not product.

The Logo system, pioneered by Seymour Papert at the Massachusetts Institute of Technology and described in his book *Mindstorms* (reference 5), is a computer-based learning environment that is particularly well suited to the kinds of individual tailoring needed by students with special difficulties. From the start, it was Papert's intention that Logo activity would involve more than learning to program. The Logo language contains a set of powerful graphics primitives, a text editor, and full list-processing capabilities. It is a good way to become familiar with programming quickly and relatively painlessly—an important issue for both teachers and children. But more than that, Logo can be extended with user-defined procedures. This extendability allows a teacher to use programming as a way into other subject areas. By a judicious selection of system-provided and user-defined primitives, the teacher and student

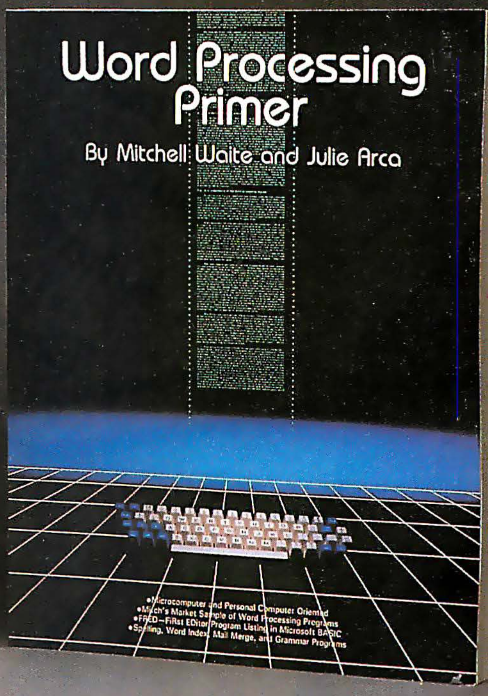
Acknowledgment
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Finally, the authors survey the current scene in terms of available software (like cross-assemblers, 8080 emulators, and operating systems for the 8086/8088) and new products such as the IBM Personal Computer, which is based on the 8088. With its thoughtful presentation aided by numerous illustrations, *8086/8088 16-bit Microprocessor Primer* will put you on the cutting edge of current microcomputer technology.

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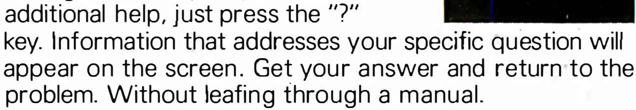
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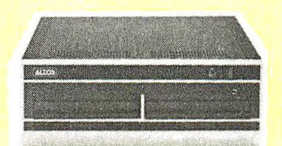
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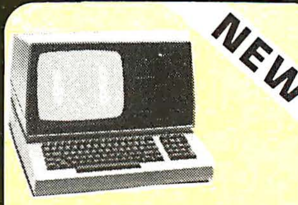


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can build bridges from an informal intuitive understanding of a piece of the world to a formal understanding of that area.

The learner benefits from the structured nature of the activities, the immediate feedback, the possibility of a concrete approach to abstract ideas, and the emphasis on the methods of doing things rather than on the answers—the emphasis on *process* rather than *product.*

During the past 10 years, Logo has been used with children of all ages and all ranges of ability. It was noticed at Edinburgh (references 4 and 13), in the Brookline project (references 7 and 14), and with a Boston Children's Hospital subject (reference 11) that children who had learning disabilities responded particularly well to the use of Logo. The MIT Logo Group has been working with physically disabled children at the Cotting School in Boston (since 1978); with autistic and other emotionally disturbed children at the League School for Autistic Children, Newton, Massachusetts (for the past year); and dyslexic children at the Carroll School in Lincoln, Massachusetts (just beginning).

For physically or learning-disabled children, the computer allows entry into worlds in which their weakest areas are not the primary means of access. For autistic children functioning at a low cognitive level we can simplify the computer-based learning environment until they are able to engage in *self-initiated and self-driven* activity. This can lead, for example, to the beginnings of an understanding of cause and effect that comes from the one-to-one correspondence between an action taken and the response it produces. Logo provides a tool for diagnosis and remediation (references 10 and 11), as well as serving as a learning environment.

In this article we describe several ways in which we have been using computers with educationally disabled children, helping them build their basic intellectual skills, while developing a stronger sense of confidence, self worth, and control over their environments. Each of the approaches is illustrated by a brief anecdote, showing how it helped a particular child make progress in learning. More detailed descriptions of these approaches and their results are available from the MIT Logo Group (see references footnote for the group's address).

A Tool for Learning and Communication

A severe physical handicap imposes a dependent, passive role on its victim. The uncompromising way in which Logo places initiative and control in the hands of the users allows them to have a direct effect on their environment. The Logo experience is often the first in which disabled students *tackle problems which require them to initiate solutions, try them out, respond to feedback, and decide whether to change track or to persist*—all those things that tend not to happen in the dependent situations that typify their lives and most of their schooling.

A major problem for severely disabled individuals with little motor control is that of being totally dependent on other people to produce a written record of their and other people's thoughts. Computer files provide a way of keeping notes, functioning as a scratch pad—try solving a complex algebraic expression or editing a manuscript without writing anything down. The effect of this unleashing of trapped intelligence can be quite dramatic.

Mike was 17 years old when he first met a computer. He has cerebral palsy, involving all four limbs, more marked on the left side. His speech is severely affected and can be understood only with difficulty. He has sufficient motor power to control his wheelchair, but has never used a pencil. For three years Mike spent 6 to 9 hours a week at the computer and was brought to the Logo laboratory weekly during vacations when the

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computer at the school was not available to him. Here is an example of Mike's writing when he first entered the Logo program.

"I ment Dr. Sileva Where, Jose Valente and Gary Drescher on October 5, 1978 at 9:32:47 AM. which the compuer I was so excized it like being it a waitting & maternace room at a hospiltal whiting to fine it oot's a boy or a grail."

Two years later he produced a letter of which the following is an extract:

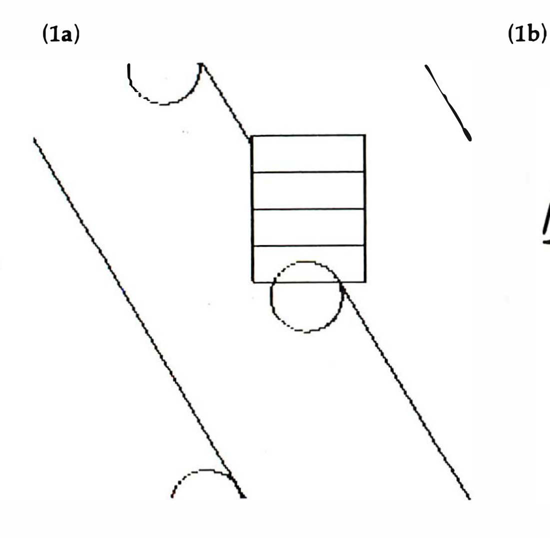
"My name is Michael Murphy. I am the person whom your mother saw on "PM Magazine." I attend the Cotting School in Boston mass. I have been work with the compuers for about two and a half years. The name of the system is "LOGO." It has open many new doors for me."

Mike has become a competent computer programmer and is now a computer science student at the University of Massachusetts, Boston campus. He is now writing papers at an acceptable level for a college freshman. Three other seniors on the project have also started computer science courses at the college level.

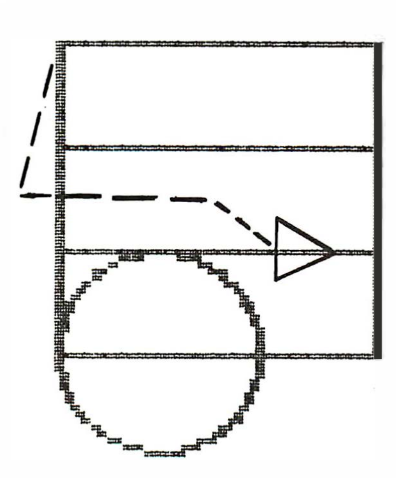
A Simpler Version of the System

For those who cannot manage as many keystrokes as Logo requires, e.g., FD 100, because of their youth or physical or cognitive disability, simpler Logo systems are easy to set up. An example is the Instant Program, on the utilities disk of Terrapin Logo (reference 1). With the Instant Program, a single keystroke will generate a turtle movement, e.g., F for forward, B for back, R for right turn. Larger primitives can be defined in the same way, e.g., a ready-made square, a quarter circle, or a triangle, each available by pressing a single key. It is also possible to record each keystroke. This allows the user to name the picture and then to use the named picture, alone or as part of a larger design, making subprocedurization possible in this simplified world (see reference 3, for a discussion of procedures and subprocedures). For some children, we have used a hardware button box. This is a plastic box with large, well-spaced

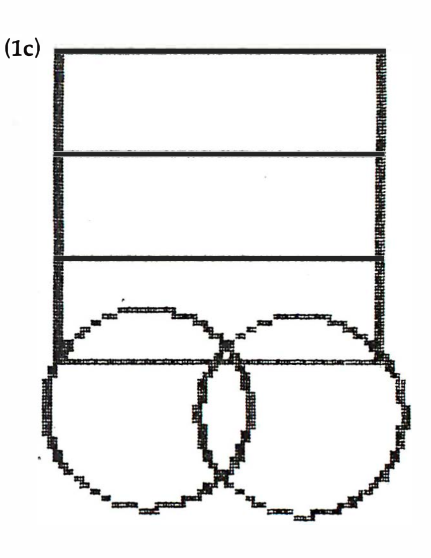
(1a)



(1b)



(1c)



(1d)

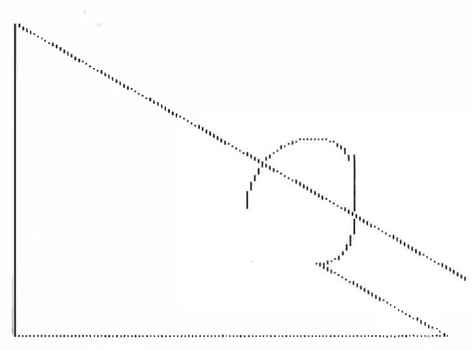


Figure 1a–d: *Ben, a 6-year-old with cerebral palsy, made progress when he was provided with a button-box interface instead of a keyboard. Figure 1a represents one of his first efforts to draw a car. By the time of his next session he had gained much more control and was able to move the turtle easily and draw a second wheel for his car (1b and 1c). The drawing shown in figure 1d was made when he went back to using the keyboard at a later session. His "ballgame," while obviously simplified, was carefully planned and executed, without the randomness associated with his initial keyboard efforts.*

buttons, each representing a primitive, e.g., FD 20 (references 8 and 13). This helps to prevent inadvertent, unintentional keystrokes, troublesome when involuntary movements are present.

Ben is a 6-year-old with cerebral palsy affecting all four limbs and speech. He makes sounds which, with patience and time, can sometimes be deciphered as recognizable words. He uses a communication board and a Handivoice. Ben was introduced to Logo using the simplified system previously described. He appeared to understand F and R but persisted in randomly hitting many other keys, often crashing the program. On these occasions he laughed uproariously at the strings of letters which would then appear on the screen. While Ben was clearly having a good time, his keyboard activity seemed unplanned and unrelated to what was happening on the graphics screen.

We substituted the seven-button hardware button box, giving him F (forward without drawing a line), T (right turn), Q (quit), a rectangle, a square, a circle, and a line equivalent to FD 10. A session or two after the introduction of the button box, he began drawing several cars. The first one looked like Figure 1a. During the next session he made a similar car and was asked, "Doesn't it need another wheel?" He paused, smiled, then moved the turtle on the path indicated in Figure 1b, carefully adjusted it, and made a second circle, as shown in figure 1c.

In a recent session, as he entered the computer room he was asked, "Do you want to use the button box today?" He indicated no. "Do you want to use the keyboard like Eva and Nicky (two of his classmates)?" Ben said, almost distinctly, "Eva and Nicky."

Back at the regular keyboard, Ben's random hitting of keys had all but disappeared. He created the drawing in Figure 1d, which he named "ballgame," typing the word into the computer himself. To us, this picture appears flat and undeveloped. For Ben, it provided a significant reference point which he used to initiate "conversations" about the ballgame he imagined.

Ben's behavior is reminiscent of the response obtained by Weir and Emanuel (reference 13), who found that an autistic child began to use language spontaneously for the first time ever during his Logo sessions. Ben's Logo work provides his teachers with a window into his thinking and a medium through which he and they can communicate. This clear person-to-person communication is not routine for Ben; it emerges out of interaction around something of his own creation, of interest to him, under his control. For nonverbal children, carefree conversation is impossible. The danger for such children is that they will limit their communication because the results are so often misinterpreted or fall so short of the complexity or length of what they would like to express. The amount of energy Ben puts into his Logo work, the effort with which he manipulates the buttons (not a trivial activity for him), and the length of time he spends before becoming tired, all indicate that this activity motivates exploration, communication, and probably language development.

Motivation to participate in the Logo project is so high that children without special adaptive devices invent their own ways of handling a

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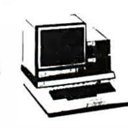
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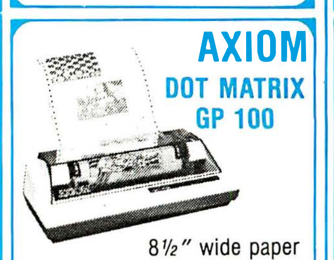
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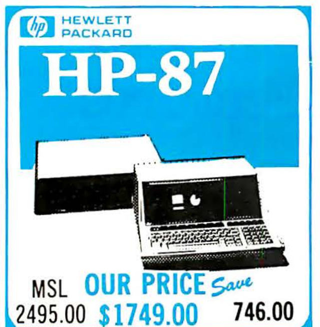
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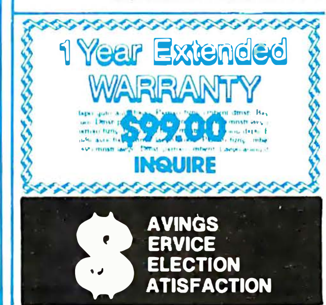
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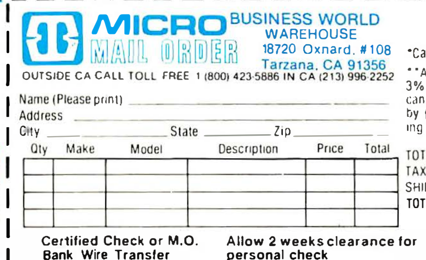


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keyboard, for example, by using a pencil between their lips. In some cases, we have seen dramatic improvements in control of direction and accuracy of arm, hand, and finger movement.

Mobilizing Existing Understanding

Experts differ from naive students in the degree of meta-level knowledge they possess. The facts of a subject are relatively easy to transmit. Learning only these, without an appreciation of their use, constitutes rote learning. Real understanding includes appropriate knowledge about when to use particular facts and operations and about how to order operations so as to achieve a particular goal. This is knowledge about knowledge, or meta-knowledge. Just how to facilitate the acquisition of meta-level knowledge is the great challenge. One possibility is to try to hook into already existing meta-knowledge.

A growing child spontaneously learns how to do certain things, including the procedural-control knowledge we are talking about. Connecting with that existing knowledge is the purpose behind the learn-by-doing school. For example, the child's intuitive knowledge of his own body movements as he navigates in space includes such sophisticated understanding. Mobilizing this to provide a way into mathematics is just what Papert has done with his turtle geometry (references 2 and 5).

Now consider the unusual childhood of an individual physically disabled from birth. If the disability is severe enough, the child will not have handled objects as part of growing up, will not have played with blocks as an infant. The development of an understanding of spatial concepts depends on a coordination of several kinds of information—tactile, visual, motor, and kinesthetic (sensation in muscles and joints of the moving part)—generated by handling objects, moving around in space, and so on. Hence the child with lack of this experience is at the risk of developing a *deficit in spatial competence.*

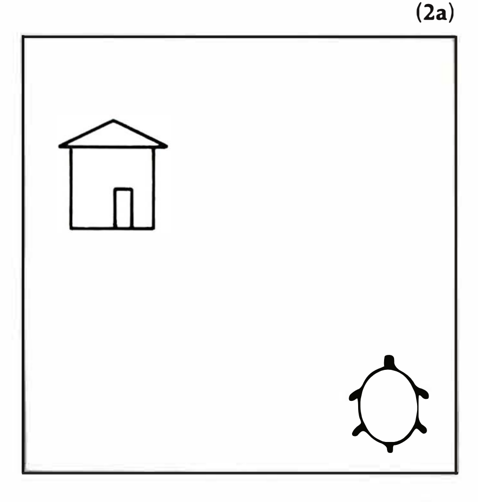
The degree of deficit is difficult to assess in individuals with severe motor disabilities. For example, when children with cerebral palsy are tested for some particular component of visual perception, they will obtain progressively lower scores as the motor component of the test increases (reference 15). It has, until now, been necessary to convert tasks such as the Piagetian Seriation task into a multiple-choice form in order to use them with people with severe motor restrictions. This precluded an examination of the processes involved in carrying out the relevant maneuvers.

We have exploited the possibilities of an interactive graphics situation by creating *graphics screen versions* of these assessment tasks. Using these screen tasks, we have found deficits in spatial reasoning in some people with cerebral palsy when they are asked to perform tasks involving ordering by length, shape recognition, spatial localization, and mental rotation. We have probed the nature of the underlying defect in several of these children (references 9 and 12). (See figure 2.)

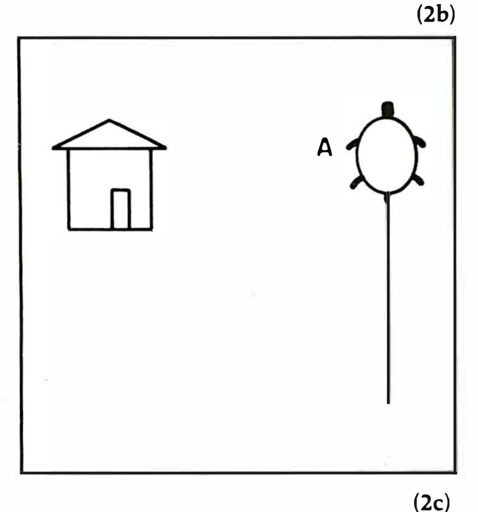
Filling the Gap with Logo

The Logo theme of the learner as model builder takes on a poignant significance for the physically disabled because lines on the graphics screen can become models of objects. Such graphics objects can supply manipulatory experience of a sort, involving a minimum of motor effort, by simply pressing a key. We have called these manipulations AS-IF actions (reference 6) and suggest that the Logo system provides a rich source of such activities. For the severely disabled child, the chance to find out about spatial relationships in the environment has been restricted by the dependence on others for mobility and by the lack of ability to draw, build, pour, pile, sift, put together, and take apart. The child can use the screen turtle to explore a defined and manageable spatial world in which to learn about shape, length, angle, size, position, and number; teachers can easily follow the process of exploration, structuring appropriate tasks as skills and confidence increase.

(2a)



(2b)



(2c)

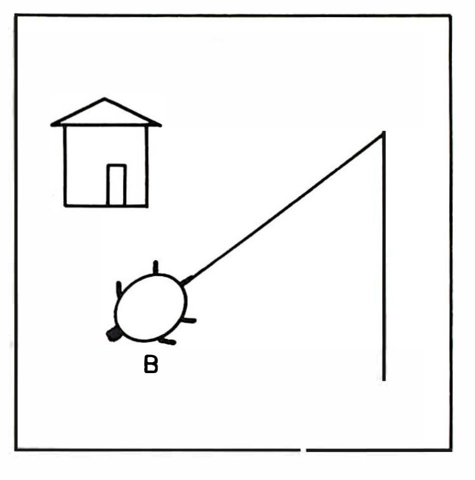
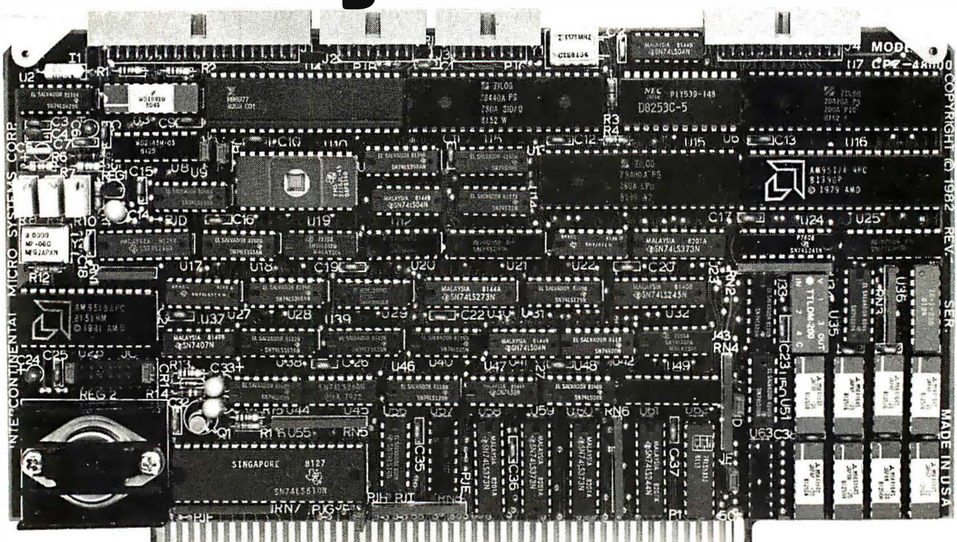


Figure 2a–c: *For Kate, a 13-year-old with cerebral palsy, the lack of meta-knowledge is quite remarkable. When asked to get the turtle into the house she moved forward unconcernedly until the observer asked, "Are you going towards the house?" (at A in 2b). She then turned and moved forward until the observer again asked the same question (at B in 2c). Kate was gradually introduced to elementary Logo. She is now defining shapes and using them as subprocedures of more complex pictures.*

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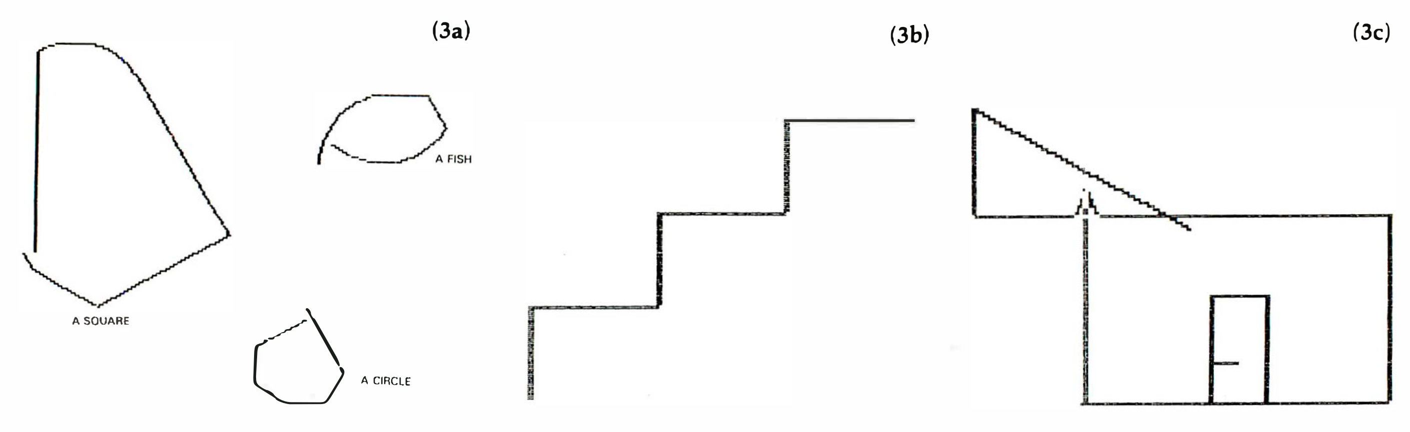


Figure 3a–c: *The progress made by Nicky, a 7-year-old with cerebral palsy, is obvious. Figure 3a shows his initial attempts at drawing, using a simplified version of Logo. His shapes were irregular and poorly defined. By his seventh session he was able to consistently make right angles, as shown in 3b, and plan and execute a large design, as shown in 3c.*

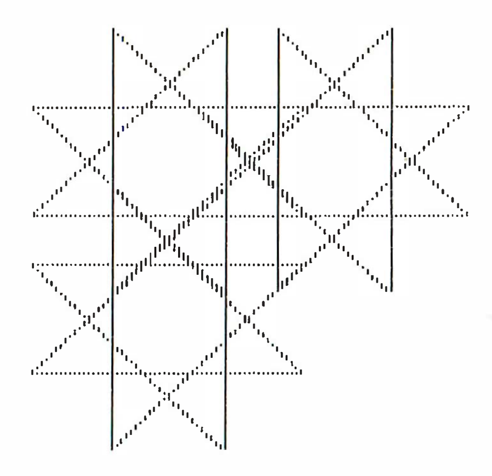


Figure 4: *This drawing shows the work of Franky, a 10-year-old learning-disabled student. His mastery of turtle geometry is shown by the skill with which he arranged the three stars into a coherent design, despite severe difficulties with "paper-and-pencil" mathematics.*

Assessment of Nicky, a 7-year-old with cerebral palsy, indicated deficits in many spatial and language skills, including the ability to count accurately more than four objects, to match a small group of objects one-to-one, and to conserve number (know that the number of objects has not changed when their arrangement is changed).

In his early work with Logo, Nicky made small, closed shapes which appeared to be unplanned. He used a small portion of the screen, had difficulty turning the turtle in the direction he wished, was unable to make square corners (requiring three presses of T) or match sides of objects. Examples of his first named pictures appear in figure 3a. His use of shapes is typical of a much younger child: he demonstrates closure but does not have firm categories for square or circle.

By his seventh session Nicky had made remarkable progress. He produced, without hesitation and without mistakes, the pictures he called respectively "STEPS," figure 3b, and "HOUSE," figure 3c, which showed the following characteristics: consistent use of three turns to make a 90-degree angle, matching of the lengths of opposite sides, use of a large area of the screen (both left and right halves), and a deliberate planned sequence to complete the picture symmetrically.

Revealing Hidden Strengths

A central issue addressed by the use of Logo with educationally disabled children is the discovery of hidden strengths. Often the needs of physically or learning disabled children become the focus of their educational experience with most attention given to learning how to cope with what they cannot do and little attention given to developing special gifts and talents. But a *physical* disability is not the only type that may hide spatial strengths. Growing evidence suggests that there is a category of learning-disabled children who have special ability in the spatial mode, an ability which is often ignored in school (reference 11).

Franky is a 10-year-old learning-disabled child. His reading and spelling are several years below expectations for his age and grade; he knows some mechanical processes for computation, but these often break down. He was described in school records as having behavior problems, a short attention span, and a low tolerance for frustration. In his Logo work, Franky showed unexpected abilities to use numbers appropriately to create relationships in space, to use units larger than one as benchmarks for estimating length, and to remember individual as well as sequences of commands after a single exposure to them. Figure 4 shows an intricate star design which he created from smaller pieces. While creating his design, he needed to move a certain distance on the screen in order to place his next star where he wanted it. The distance was half of 75—a problem he is unable to compute. He looked at the distance on the screen and said, "Oh—it's about 37." An observer might think this was a lucky guess if he did not make such "guesses" with regularity.

Franky seems to have some of the skills he needs to manipulate numbers when he uses a spatial model but does not have the meta-level knowledge necessary to translate this understanding to a purely numerical situation. If given a spatial model which he can use to figure out a problem, he can use it successfully, but the *idea* of using the spatial model does not oc-

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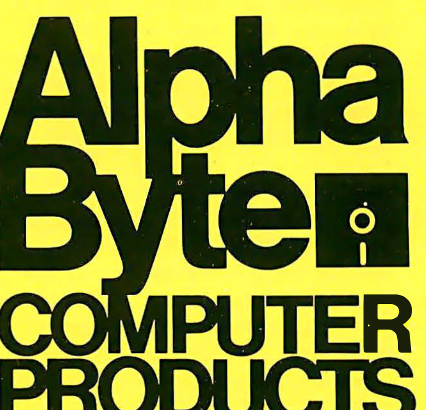
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cur to him independently if he is presented only with the numbers.

Many children like Franky have learning problems that are exacerbated because schoolwork in their weak areas is presented to them in their weakest mode. For these children, who are used to failing in school, the impact of Logo is threefold: (1) it provides the possibility of experiencing success and demonstrating expertise; (2) it allows further development of the preferred spatial mode; (3) it is a diagnostic tool which suggests to teachers ways of creating more appropriate curriculum by harnessing spatial skills.

Equal Access in a Technological World

It is important to attempt to lay to rest a serious misconception about computers in education. The connection of children and computers does not diminish the teacher's critical role in the learning process. On the contrary, because interaction with a computer opens a window into a child's thinking processes, a teacher is challenged to observe carefully, to develop hypotheses about the child's strengths and needs, and to help structure next steps for the learner. The questions for a teacher are the same here as in any educational situation: When should the teacher pose a new problem? When should the child be left alone to explore the possibilities? When should help be given and how much? How much frustration is appropriate in a new problem-solving situation? The computer can also become a powerful tool for the teacher in devising specific curriculum tailored to children's needs and harnessing the power of both graphics and text capabilities. Teachers have used or are developing Logo programs for teaching mathematics, physics, electronics, music, writing, and spelling.

We are only beginning to understand the extent to which the educationally disabled have been denied rights and opportunities. A user-controlled, flexible, extendable computer language is a powerful tool that can help bridge some of the gaps by increasing educational access, expanding choices, improving communication, and enabling development of skills for vocational success and personal enrichment. ■

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Photo 1: *As slain pirates lie in heaps on the deck, the swordsman prepares for another attack.*

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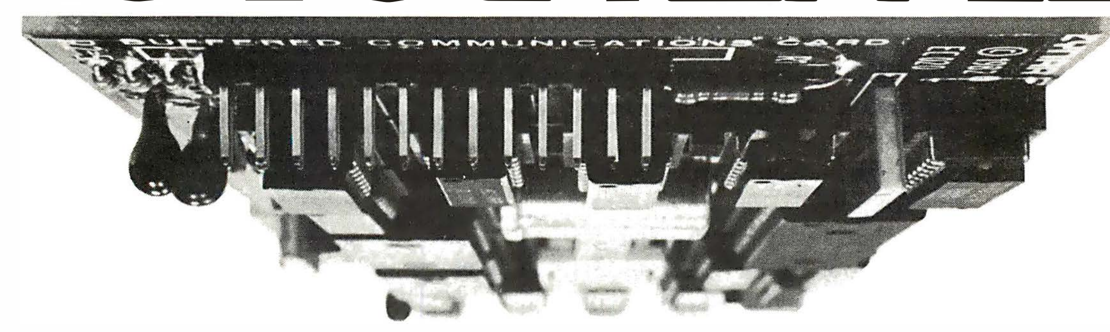
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Pressing any key will revive you. It takes a little practice to avoid standing up in the middle of someone's weapon and impaling yourself.

Before too long, when the giant would bring up his club for a blow, I was able to capitalize on the opening. When struck, the giant drops his jaw in surprise, lets go of his club, and slumps to the floor. In fact, each pirate reacts in a fairly realistic fashion to being stabbed or slashed.

You will meet up with several adversaries during the course of a game and, the farther along you get, the more you meet. (I encountered seven characters during my struggles.)

At a Glance

Name
Swashbuckler

Type
Arcade-style game

Manufacturer
Datamost
9748 Cozycroft Ave.
Chatsworth, CA 91311
(213) 709-1202

Price
$34.95

Author
Paul Stephenson

Format
5¼-inch floppy disk

Language
6502 machine language

Computer
Apple II with 48K bytes of memory and one disk drive (DOS 3.2 or 3.3)

Documentation
Two pages

Audience
Game players

The Game

You meet new adversaries in pairs, or actually waves of pairs. The first adversary in the pair will appear on the right-hand side of the screen. If you defeat him, his partner will immediately appear on the other side. That's your pair.

If you defeat the second character, you will have to contend with both of these adversaries at once—four, five, or nine times! That's a wave, and there are two waves for each scene after the first. In the first scene, there is only one wave, but you must defeat both members of the pair nine more times. The pair in the first wave of scene two will attack you six times, and the pairs in every wave afterward will attack five times.

You get one point for each pirate you defeat. The scene changes at 21, 43, 63, 83, and 103 points. I don't know how many scenes there are beyond that, because my high score is 112 points.

The pirates have trained pets that join in the attack against you at both regular and random intervals. You don't get any points for killing an attack pet, but doing so can help you get to the next scene. Sometimes you may



find yourself simultaneously fighting off two pirates and two attack pets, which are rats, cobras, spiders, and scorpions. As mentioned above, you are provided with a low parry to fend off their attacks. However, you can't move and keep the low-parry position at the same time because moving always returns you to en garde, so a certain amount of forethought must go into your movements.

In addition, the pirates you face change in some significant manner at each new scene and at 33, 53, 73, 93, and, probably, 113 points. The first two times, the change is to a new pair of adversaries. After you meet the first six pirates, the adversaries change in the way they are paired against you. The next change involves an even greater increase in speed, which forces you to treat supposedly familiar assailants with an entirely different set of tactics. At 83 points, some new characters begin to appear. The further along you go in the game, the faster and more aggressive the pirates are. After each wave, the pirates revive closer to the spot where you dropped them. When this starts happening, you should kick the body toward the edge of the screen before you meet the other attacker.

Cast and Crew

After playing the game several times, I began to nickname each of the pirates (with apologies to Datamost). I call the first pirate Baldy Spikeclub. As long as Baldy keeps his club in front of him, he completely guards himself from your attacks, but he can't break through your guard as long as he stays in that position. When he raises the club, he is both dangerous and vulnerable. He's vulnerable because as soon as he moves his arms up or down you have an opening. Dangerous, because he can now kill you, especially if you thrust or lunge from too close in. He moves that club very, very fast even on the lowest level. When he appears again later in the game, he wields the club so fast that he's in a true rage and one of the toughest characters to defeat.

His partner, Ratface Daggeraxe, is relatively easy to dispatch once you learn not to let him and his ax get too close. He's usually so busy waving his weapon and looking ugly that he forgets to defend himself. Datamost should consider making this character fight more effectively, as he rapidly becomes a boring opponent.

The first character you meet in the second scene is Buccaneer. He's one of the two or three toughest characters I encountered, particularly on the higher levels where all the pirates move quickly. The first time you meet him, he swings his cutlass with alarming speed and can often reach much farther than you thought. Because he moves so fast, it can be very difficult finding an opening.



However, there are two times when you can get past his guard. First, from time to time, Buccaneer will raise his cutlass high above his head. It's not only a dramatic pose, but an ideal opportunity for you to skewer him. The other occasion when you are likely to connect is when he follows through after one of those dramatic cuts and his sword is still down. If your timing is right, your blade can find an opening.

Buccaneer's partner on this level is obviously a veteran of many such battles because he wears a patch over one eye and has a wooden leg. His favorite piece of mayhem is slashing your leg to maim you. Like all of the pirates who come from the left side of the screen, though, he is not nearly as challenging to deal with. This is not to say that he's always a pushover like Ratface. He is much more apt to get through your guard, particularly if you advance when you should be falling back or if you carelessly lunge at him from too close.

Shufflefoot Spearpoker doesn't throw his weapon (none of your foes in this game do), but he certainly does move his spear around in a menacing fashion. You have your best chance to defeat this character when he is waving his spear and it's not pointed directly at you. Sometimes you can reach him even when the spear is aimed straight at your heart, but I don't recommend it. Although he looks as if he's about to fall over backward, Shufflefoot moves a good bit faster than some of the other characters. He can slip his spear under your sword arm even when you're sure that you are well protected.

The Harpoon Hustler is best handled with a kind of determined patience. He is the most aggressive pirate up to this point; if you leave an opening, he'll find it. When he has his harpoon pointed at your belly you are completely blocked from hitting him. You can goad him into trying to take a swing at you by alternating between attacking and retreating. Usually, I end up thrusting time after time until I find an opening by chance.

The Samurai handles his sword with the style you might expect; very impressive animation. He is also unbelievably fast. Surprisingly though, he is not as hard to defeat as either Buccaneer or Baldy Spikeclub. In spite of his speed, if you hold a thrust or lunge position, the Samurai will eventually impale himself on your saber. Although harder to defeat, he's comparable to the Harpooner or the Buccaneer.

The pet rat always appears from the left side of the screen. If he bites, you're not dead, but you won't be able to lunge until you are struck down and then revived. Slice down with a low parry and the rat will disappear before your eyes.

The cobra can really move fast! This lovely pet is just as easy to dispatch as the rat, if you are quick, but it's apt to surprise you. The cobra first appears in scene one, but he can appear at odd moments throughout the game. Its bite is deadly.

The other two creatures are the spider and scorpion. Their graphics are especially well done. Both first appear in scene two and randomly throughout the game thereafter. Your defense here is also the low parry.

Game Strategy

A player can do fairly well in the lower levels of this game by attacking whenever possible. Proceeding further requires a certain amount of strategy. Never lunge when a simple thrust will do: you are likely to lunge right into your opponent's weapon. Try to give yourself as much fighting room as possible. Remember to meet each pirate on his side of the screen, because this keeps you from getting caught between two enemies with nowhere to retreat. Also remember to kick the bodies out of the way to create fighting room or you will find pirates stabbing you in the back the moment they are revived. When you cut down the second pirate of a pair, you should stay close to the place where he will be revived so that you can hold out your sword and impale him again when he stands up. Finally, watch out for those nasty creatures on the floor. If an attack pet comes toward your back while you are busy with a fight, you should deal with it first and then return to the fight.

I think that most arcade-game fans will find Swashbuckler an enjoyable experience. The title page and some of the scenes are a little sloppier than you might expect in a $35 game, but the animation is a real winner. The need to plan your moves and to use strategy elevates Swashbuckler well above the run-of-the-mill arcade game. I'm not finished playing yet. ■

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Zero Gravity Pinball

Mark Friedman
23 Forge Dr.
Nashua, NH 03069

Thoughts of pinball bring back fond memories of pizza parlors and pool halls, but no pizza parlor or pool hall yet built has a game anything like Zero Gravity Pinball. In fact, you won't be able to find a pizza-parlor version of Zero Gravity Pinball until orbiting space stations become commonplace. The game was written for the Apple II by Don Fudge and is marketed by Avant-Garde Creations.

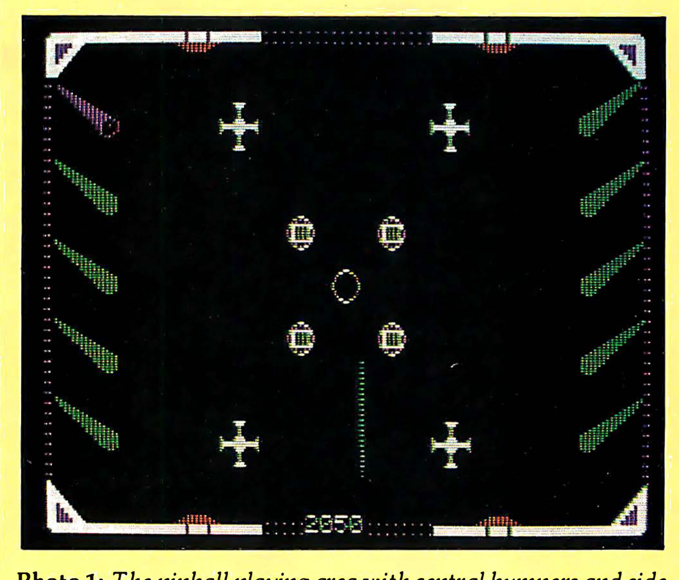


Photo 1: *The pinball playing area with central bumpers and side flippers.*

True to the traditions of its earthbound predecessors, Zero Gravity Pinball challenges you to score as many points as you can using flippers to keep the ball in play. Without gravity's influence, the ball moves in a straight line until it hits an object or moves off the playing area. Furthermore, instead of the traditional two flippers, you have 10, five on each side of the playing area.

Getting Started

The instructions for playing the game are printed on the back of the package wrapper. Although the instructions are otherwise quite detailed, I found one serious omission: how to start the game. Fortunately, start-up is a simple process: insert the disk into drive 1 and boot up normally.

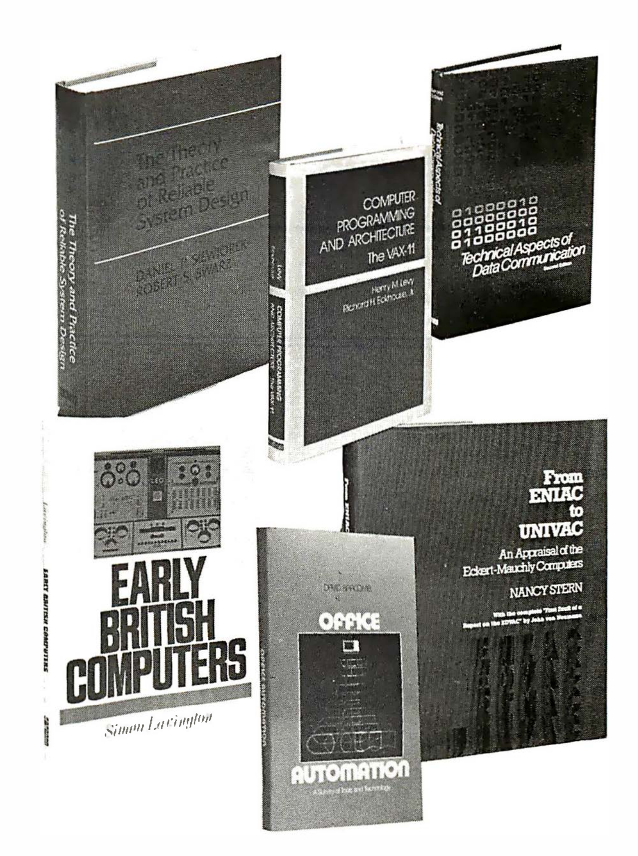
After the program boots up, you'll see the title page. Press any key to continue and the credits' screen will appear. Next, you are asked if you would like instructions. The on-screen instructions repeat the information from the printed documentation. It now takes about 40 seconds for the game to load.

Next comes your most important decision of the next couple of hours: which level of difficulty do you want? The levels range from 1 (slow) to 5 (masochists only). Another brief delay follows, during which you should grab game paddle 0, because the first ball is automatically released.

The Layout

As you view the playing area (see photo 1), you'll notice some of the unique features of Zero Gravity Pin-

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At a Glance

Name
Zero Gravity Pinball

Type
Arcade-style game

Manufacturer
Avant-Garde Creations
POB 30160
Eugene, OR 97403
(503) 345-3043

Price
$29.95

Author
Don Fudge

Format
5¼-inch floppy disk

Language
6502 assembly language

Computer
Apple II with 48K bytes of memory, Applesoft in ROM or Language Card, one disk drive (DOS 3.2 or 3.3), game paddle 0

Documentation
One-page card

Audience
Arcade enthusiasts of all ages

ball. The playing area is square, with gaps (indicated by dotted lines) on all four sides. The game begins when the ball appears from the central bumper and starts its journey. The ball can also disappear there, as this bumper occasionally turns into a hole, but there's not much you can do about that.

Before turning to the flippers on each side of the screen, a word about those openings at top and bottom is in order. To keep from losing the ball in the lower opening, you must press the space bar before the ball enters the void; if you're too slow, the ball explodes. To guard the upper opening, press any key *except* the space bar. These protective "force fields" have a limited range and have no effect unless the ball is about to exit from the top or bottom of the screen.

The Flippers

The primary challenge of Zero Gravity Pinball is that you need three hands to play, because, while worrying about which key to hit next, you're busy twisting away at the game paddle to control the flippers. Although there are 10 flippers on the screen, only one is in play at any given time. To select a flipper, turn the game paddle until the desired flipper changes color from green to red. Then press the paddle button to flip the ball back into play. The flippers, like the upper and lower shields, are active only when the ball is nearby.

The flippers are not solid, but rather are "force fields." As a result, the ball will go through a nonselected flipper, causing it to vanish until you select it, or until the next ball is released.

At this point, you're busy paddle twisting, button pushing, and key pressing, so a word of warning may be appropriate. Every once in a while a flipper may be red, but in fact be a useless "bogey," or even worse, a white "superbogey": there, but not there. In either case, just turn the paddle knob back and forth to restore normal functioning. Occasionally, the top two flippers will act as if they were solid even though they've not been selected.

Scoring

Once you've accumulated 50,000 or more points with the five balls you are allotted, it's time to move up to the next level of difficulty, because a score of more than 64,000 points ends the game. While I'm reluctant to reveal my top score, let me assure you that it was nowhere near that level. If you have a joystick and a steadier hand than mine, flipper selection should be easier and faster, and your scores higher.

While the screen layout is relatively simple, particularly compared to some of its earth-based predecessors, the quality of the graphics and animation is excellent, and its color and sound are good. Even at level 5, the ball's movement was quite smooth—though moving too fast to provide much opportunity to keep it within the playing area. In fact, the press release accompanying the review copy indicated that anyone able to hit the ball more than twice at level 5 was worthy of a plaque.

Conclusions

While it has some similarities with other pinball games, Zero Gravity Pinball takes much longer to master than the more familiar two- or four-flipper games.

The five levels of difficulty allow almost anyone to enjoy the game, while providing lots of challenge for the most accomplished player.

Zero Gravity Pinball is an original and unique game that makes excellent use of the Apple's graphics capabilities. It may be one of the best tests of eye-hand coordination around, as well as being a lot of fun. ■

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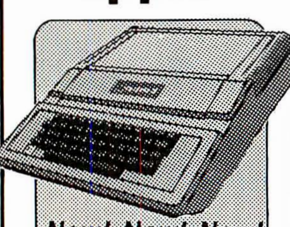
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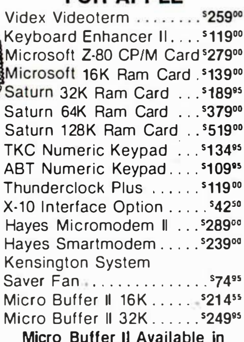
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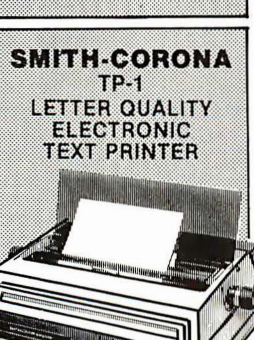
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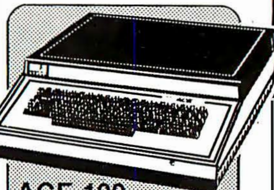
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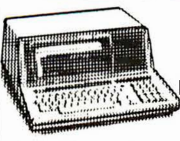
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Beer Run

Arthur Little
Technical Editor

Beer Run—a game with a straightforward purpose. No longer shall I dwell in a maze of twisty tunnels, watch my cities get nuked, or send another Federation Starship into ignominious defeat. No indeed, because from now, I'm a Beer Runner with only one goal in mind: collecting lagers.

In the interest of accuracy (and decorum), I should point out that this Beer Run is of the nonalcoholic variety provided by the folks at Sirius Software. In fact, Beer Run is a high-speed, color-graphics game designed for the sober and studious Apple II user. Studious, anyway.

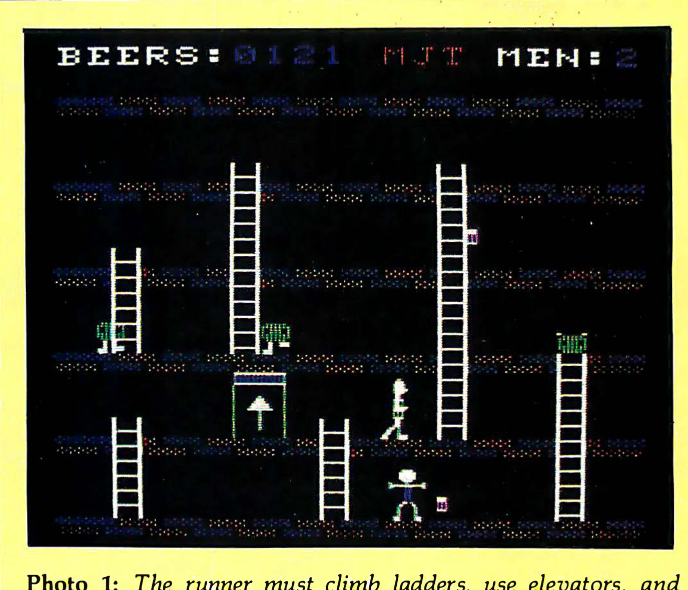


Photo 1: *The runner must climb ladders, use elevators, and avoid Bouncers and Guzzlers.*

Your Goals

According to the documentation, the object of the game is to catch the elusive Artesians as you move through the levels of the building. It goes on to say:

Usually they (Artesians) will be on the platforms just above you. Ladders and elevators are used to climb upward through the Sirius Building. If you reach the roof, the Sirius blimp will transport you to the roof of the Olympia Brewery building next door.

Basically, the idea is to climb to the top of the first building, cross over to the second building, and then descend. This is a cross-section, multilevel game that is faintly similar to the arcade game Donkey Kong or to the well-known Apple Panic (see Gregg Williams's "Apple Panic," March 1982 BYTE, page 68). It's also reminiscent of the children's board game Chutes and Ladders in that the runner strives to go up and (too often) ends up back at the bottom.

You also want to increase your score, based on the total number of beers that you collect during your hunt. You collect beers in one of four ways:

1. The unseen Artesians will drop individual beers from above. If your runner's hand touches one as it falls, it's added to your cumulative score.
2. As you move up and down through the building, you may run across beer kegs. If you press the space bar as



At a Glance

Name
Beer Run

Type
Arcade-style game

Manufacturer
Sirius Software
10364 Rockingham Dr.
Sacramento, CA 95827
(916) 366-1195

Price
$29.95

Author
Mark Turmell

Format
5¼-inch floppy disk

Language
6502 assembly language

Computer
Apple II or II Plus with 48K bytes of memory and one disk drive (DOS 3.2 or 3.3)

Documentation
Two-page folder

Audience
Apple owners and game lovers

you pass the keg, its numeric value is added to your score.

3. Riding either up or down in an elevator gives you a minimum of 25 beers—and often more.
4. Finally, you get beers for successfully negotiating the interbuilding blimp ride.

Play Commences

After booting the disk, the title pages come on screen and you are introduced to the two creatures you'll want to avoid during your search: the Guzzlers and the Bouncers. If your runner comes into contact with either, the runner plummets to his death—you are given three runners per game.

When the game begins, you see the first five levels or platforms. As you move up and down throughout the building, you will see a tier of five levels (e.g., Levels 6 to 10), each with a unique pattern of connecting ladders. (See photo 1 for a view of Levels 6 to 10.)

The Controls

Your runner edges along the platforms and climbs the ladders. You control his movements using the keyboard

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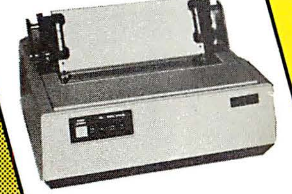
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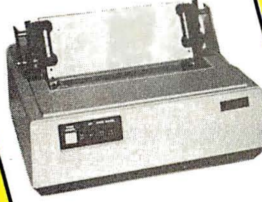


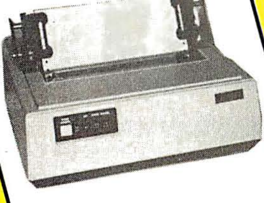


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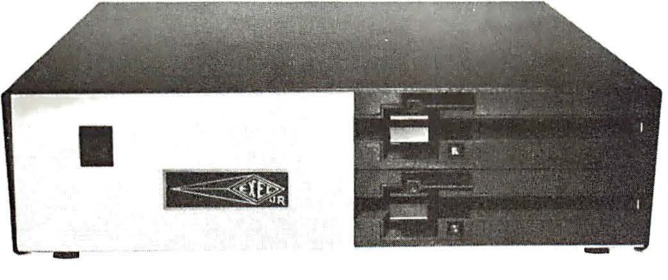






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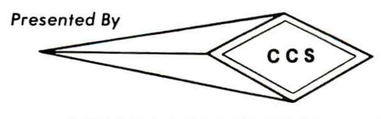
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or game paddle. Using the keyboard, you press the left or right arrows to move left or right. To climb a ladder, you station the runner at the bottom and press the space bar. For a multilevel ladder, each time you press the space bar another level is scaled until the top is reached. Descending a ladder is trickier. The runner can go down only one level at a time, beginning at the top of each new ladder. Again, you must press the space bar. (That is, you must find a ladder that ends on the platform you are walking on.)

To move between tiers, your runner must ride an elevator, which will appear anywhere on the five platforms in view. Furthermore, it may be headed up or down. Because it is on the screen for short periods of time, it's often a good idea to get to the elevator as fast as possible. Once the runner disappears behind the elevator door, press the space bar and the ride will begin accompanied by appropriate sound effects.

The only other controls of note are the ESC key, which feeezes all action until pressed again; CTRL-S, which toggles the sound on or off; and CTRL-R, which resets the game.

Tactics, Strategy, and Stayin' Alive

Because the runner always begins a tier at the lowest row, one of the first things you'll notice is differences in the Bouncer's and Guzzlers' motions. The Bouncer can start at any of the four upper platforms; moving back and forth like a sentry, his speed ranges from very slow to very fast (depending on the level). The Guzzlers—and they are always in multiples—begin on the third and fourth levels above the runner and attempt to track and kill him. The Guzzlers' major weakness is that they usually change direction when they reach a wall, ladder, or platform. For example, they will descend only one ladder level at a time; therefore, the runner can move toward them with some confidence that they will move away. This pattern is more than compensated for by the fact that the longer the runner stays within a given five-level tier, the more Guzzlers will arrive!

In *pre-desperate* situations, I have been known to press the ESC key to get a more leisurely overview of the activities. It doesn't help much, but I still do it.

Scoring Beers

The problem with trying for the individual beers falling down is that, for me, it's just not cost-effective. Stopping for the kegs also slows one down, but I do collect them in two circumstances: when the runner is very near the elevator and I'm feeling confident or if I'm trapped and facing certain doom anyway. For consistently high scores, look to the elevators and the blimp.

Catching the Blimp

The documentation tells you to catch the blimp, but not how to do it. Here's the trick: the blimp moves across the screen from left to right, so position your runner on the left side of the roof. The blimp will be trailing a rope from its stern. Move your runner across the roof beneath the rope and wait for it to descend. Then press the space bar. Try to catch the rope on the first flyby for extra points.

Conclusions

Beer Run is witty, well thought out, and well executed. The musical sound effects are coordinated to your on-screen fortunes and add a comic relief to the proceedings. However, I appreciated the inclusion of an audio off/on switch within the program.

I enjoy the increasing difficulties encountered (more Guzzlers, tougher layout) the further I progress, so the game remains a challenge.

Though I have yet to sight, much less catch, an Artesian, I'm not about to quit. Beer Run is a hearty brew of a game. I'm sure you'll be amused by its impertinence. ■

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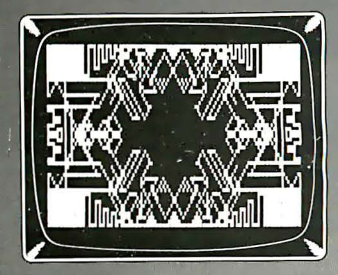
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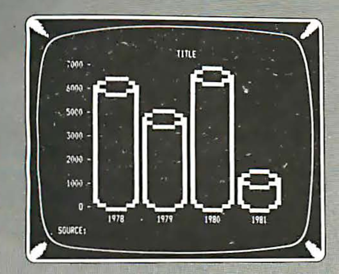
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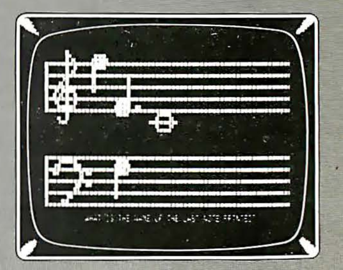
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Advanced Star Raider Tactics and Strategies

C. Donald Harris Jr.
508 Misty Lane
Friendswood, TX 77546

I assume that by now most people who own both an Atari 400 or 800 computer and the Star Raider game cartridge have either reached some level of proficiency or given up the challenge entirely and gone on to other interests. This article is directed toward those of you who have mastered the easier levels of the game, who thoroughly understand Atari's *Star Raider Users Manual*, and are ready to attempt more hazardous adventures.

From my viewpoint, the four levels of difficulty should be considered in two groups:

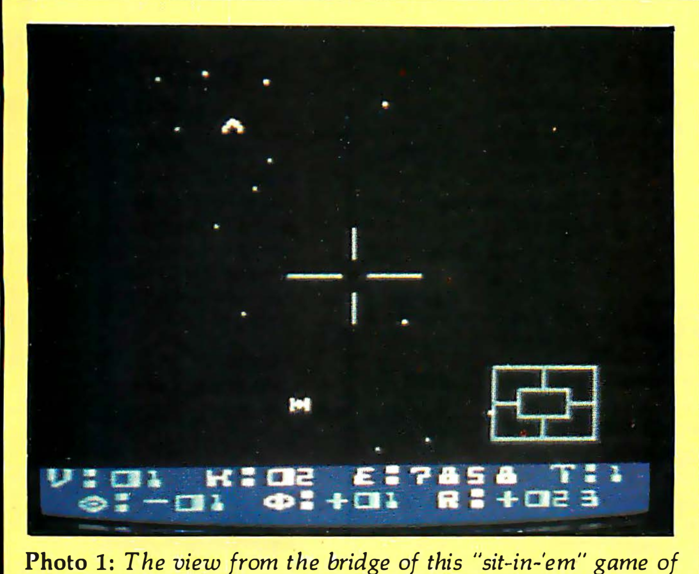


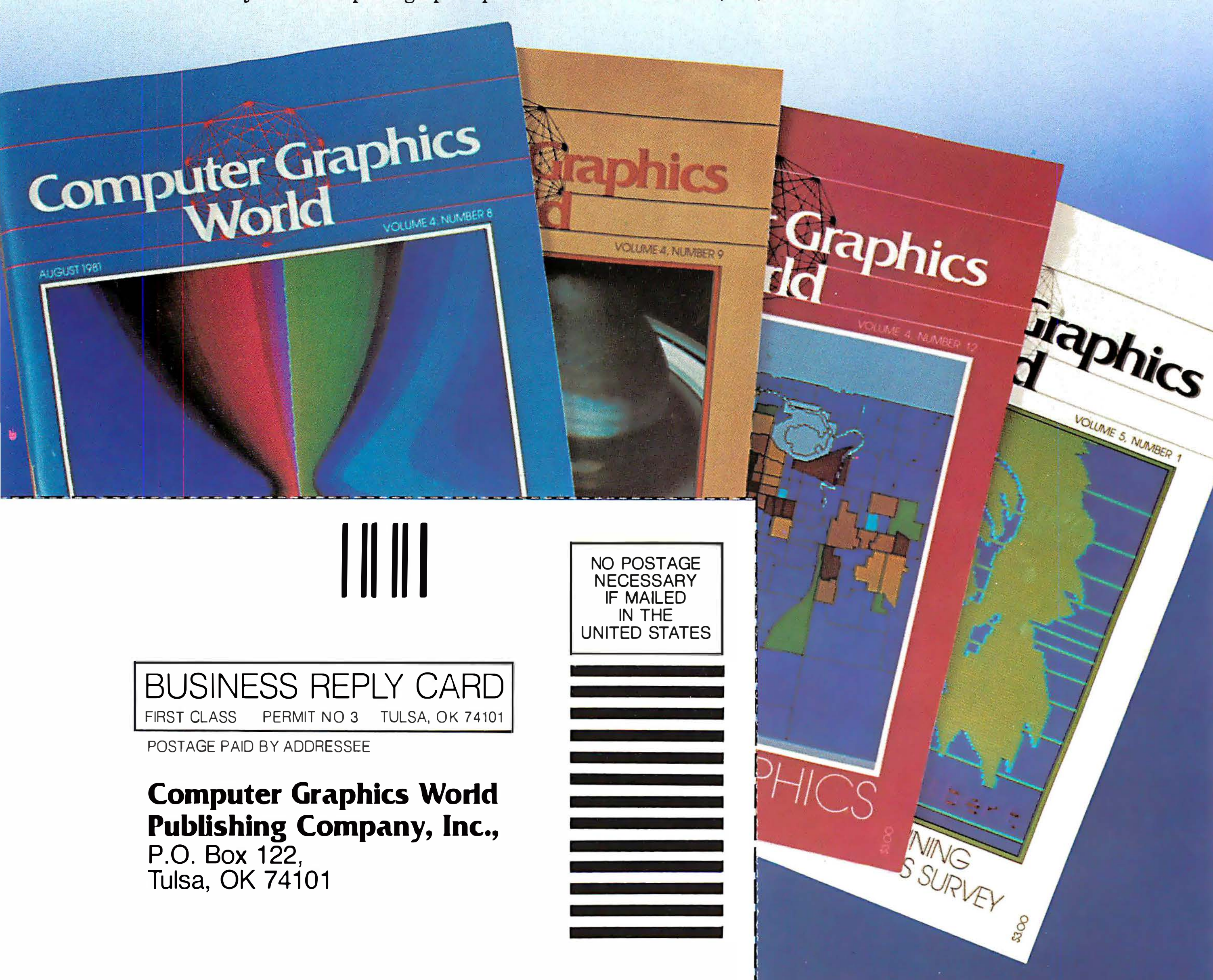
Photo 1: *The view from the bridge of this "sit-in-'em" game of galactic strategy.*

- The beginner group (Novice and Pilot levels) will be entirely satisfying for those of you who enjoy the game but wish to avoid addiction. At the beginner levels, your ship is small, almost indestructible, and will only be attacked from the front.
- The expert group (Warrior and Commander levels) requires considerably greater skills. Your ship is larger, more vulnerable, and will be subjected to aft attacks or even simultaneous front and aft attacks.

I look at the Warrior level as basic training for the Commander level and suggest that your advanced training begin with that approach. Don't expect much in the way of rank at the Warrior level—the game-completion bonus is too low. A week or so of practice at the Warrior level will sharpen your skills considerably and, with the tips provided in this article, you should be prepared for mastery of the Commander level.

Overall Strategy

You should first reach a fair amount of proficiency at the Pilot level. For example, you should be able to fly "on instruments." Without stopping to think, you should know at once where *the Enemy*, the Zylon, is from the azimuth, elevation, and range instruments on the display and which way to move the joystick to maneuver your



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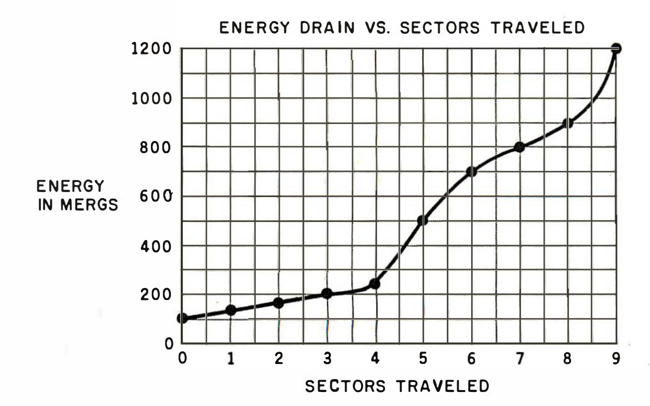


Figure 1: *Energy drain for hyperwarp engine use. The drastic increase in energy use over distances greater than four sectors emphasizes the need to plan movement within the galaxy so that only short jumps are required.*

craft. You should also know how to conserve energy during hyperwarp and when using the twin ion engines.

To properly prepare to wipe out your enemy, your battle plan should be designed around three priorities: survival, defense of starbases, and energy conservation. The main objective of course is survival (no easy task at the Commander level).

To begin the attack, switch to the Galactic Chart and press "P" (the Pause command). Now, it's study time: note the locations of your starbases in relation to the enemy's ships. This should help you plan your hyperwarp jumps from sector to sector more efficiently. The early-game strategy for defending starbases will include determining the starbase under attack and eliminating the fastest-moving enemy squadrons first. (Never go after a four-ship enemy squadron first, because you will find a starbase surrounded before you know it.)

You won't be able to figure out which starbase is first on the Zylons' hit list right away. It may take 150 to 200 centons (time units) of tracking enemy squadron movements to decide. In this interval, you should have blitzed your second or third two-ship squadron. Pick a nearby two- or three-ship fleet (they are faster!) and attack it. A caution: don't stray too far from the galactic center until you're certain which starbase to defend. You don't want to waste energy crossing the entire galaxy to begin your starbase defense. Don't forget about passing centons. Check the galactic chart during lulls in the fighting and note enemy-squadron movement. Don't forget to make your hyperwarps short jumps to save energy. Figure 1 shows the energy units used compared to hyperwarp distances out to nine sectors. Notice the large energy increase for five sectors or more, and again over eight sectors. Once you've identified the starbase under attack, mop up the sector you are in, if you feel there is time, and move to defend your starbase.

As your attack continues, you should stay near the starbase under attack and let the Zylons come to you; but watch the tricky Devils—when you least suspect it they will switch starbases and begin moving to a new target. Continue to wipe out the two- and three-ship fleets first. Once you've done that, the pressure is off your starbases. Now that I've laid out the overall strategy, let's proceed with the fun part: wiping out the evil vermin.

Behind Enemy Lines

While in an enemy sector and attempting to destroy Zylons, your objectives are survival and energy conservation. The main energy drains inside the sector result

Text continued on page 392



Videosyncrasies

Anyone who has not been a Star Raider might not understand the fascination that envelops one when playing the game—the many hours that go into learning how to swerve away from incoming photon torpedoes, the frustration of losing control of the ship while in hyperspace and then emerging in some empty nether region of the galaxy while the dastardly Zylons surround and destroy your last starbase. Atari's Star Raider is the first, and so far the best, of a genre that I call "sit-in-'em" games.

Let me explain that, as a Star Raider, you are actually sitting in your ship, seeing stars, Zylons, starbases, and the rest of a vast galaxy whiz by as if you were looking out a window. Don't confuse Star Raider with the more common "map" games like Space Invaders or Pac-Man, where you look down at a map of yourself and your opponents. In Star Raider, you are pilot of a one-man ship with all the expected properties of a military vessel capable of roving the galaxy: it has weapons, defenses, and communications equipment; it has inertia; it can be damaged and, when it is, you are in trouble.

Although map games have their place (as evidenced by the continuing popularity of chess), this is the type of game that best employs the power of the computer, because it uses the computer to give you capabilities that would otherwise be impossible. It puts you somewhere you could not normally go. I must admit that "sit-in-'em" games are now the only type I will stoop to conquer. My jaded imagination can no longer be excited by watching my "blip" shoot at the computer's "blip" on a screen—too impersonal.

Star Raider is probably the single greatest contributor to the sales of Atari's 400 and 800 series computers. People seem to buy the computer just to get the game, and then they find out that it can be useful in other ways too (but Star Raider still gets top priority). If you're thinking about writing a game for personal computers, Star Raider is the one to beat.

Here's a collection of notes and observations I have

Text box continued on page 388

A Computer That Writes Programs For You.

What will they think of next . . . ?

Technical Review
by Wayne Hepburn

QUIKPRO + PLUS is a new breakthrough in software for microcomputers from ICR-FutureSoft.

Until now, whenever you wanted a new separate program in BASIC (Microsoft Basic/MBasic/Basic 80/Oasis Basic), you had to spend a lot of dollars for it, or a lot of hours creating it (if you have the know-how). That's all in the past now.

Anybody who can turn on a computer can write a program, quickly, with this new *Quikpro + Plus* software which generates programs for you. *Quikpro + Plus* is the invention of Joseph Tamargo of Florida. His brilliant approach to program writing allows you to tap the real power and speed of your microcomputer, and it is about time this happened.

I interviewed him to find out more about *Quikpro + Plus* and pass this valuable information to you. He told me "The best part of this software is that it gives you a separate custom program every time you use it. The resulting program is produced, error-free, in BASIC (Microsoft Basic/MBasic/Basic 80/Oasis Basic, as appropriate to your system) for you by *Quikpro + Plus*. What's more, you can list your new program, look at it, see what makes it tick, and modify it as you wish."

You can also, customize, enhance, alter, and even copy the programs you create with *Quikpro + Plus*. This is because programs created by *Quikpro + Plus* are structured, easy to follow, and include many REMARKS statements right in the program listing. I don't know of any other software with the flexibility and ease of use I found in *Quikpro + Plus*.

HUNDREDS OF APPLICATIONS...

For Education, Business, Hobby, Home, Science, Personal, etc. a partial list includes programs like these: Financial Forecasting, Expense Planning, Data Access and Retrieval, Modeling, Record Keeping of all kinds, Statistical Data Banks, and much, much more. *Quikpro + Plus* cuts the time it takes to generate a new custom program down to a few minutes. That's true. I saw a letter from a user who created a separate program in Basic within fifteen minutes after reading the clear, simple, complete Documentation & Operating Manual for *Quikpro + Plus*. The software will generate File Handling and Data Entry Programs in a file format, drawn right on the screen by user. Programs created by *Quikpro + Plus* produce standard ASCII Data Files allowing data to be easily accessed by other programs, other micro's, and even main frames.

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You can perform all manner of computations among various fields in each record. You can selectively calculate and print resulting data only, or Data Base and results, or alter Records by calculation results, and so forth. The possibilities seem unlimited. And keep in mind that the power and features I am talking about end up in the separate new custom program *Quikpro + Plus* writes for you.

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Text box continued:

made after, literally, several hundred hours of playing the game. These tricks and considerations, as well as those Mr. Harris mentions, are the ones that I now employ whenever I play Star Raider. If you are a beginner to the game, perhaps you might want to consider waiting to read this—a large part of the enjoyment of the game is learning how to win.

Understanding the Zylons

- *Never lose sight of the fact that the name of the game for the Zylons is destruction of your starbases. To do this, they surround a starbase, cut off its supplies, and kill it, then build two ships out of the wreckage.*
- *Once a starbase is surrounded, you have only a certain amount of time to save it.*

Planning

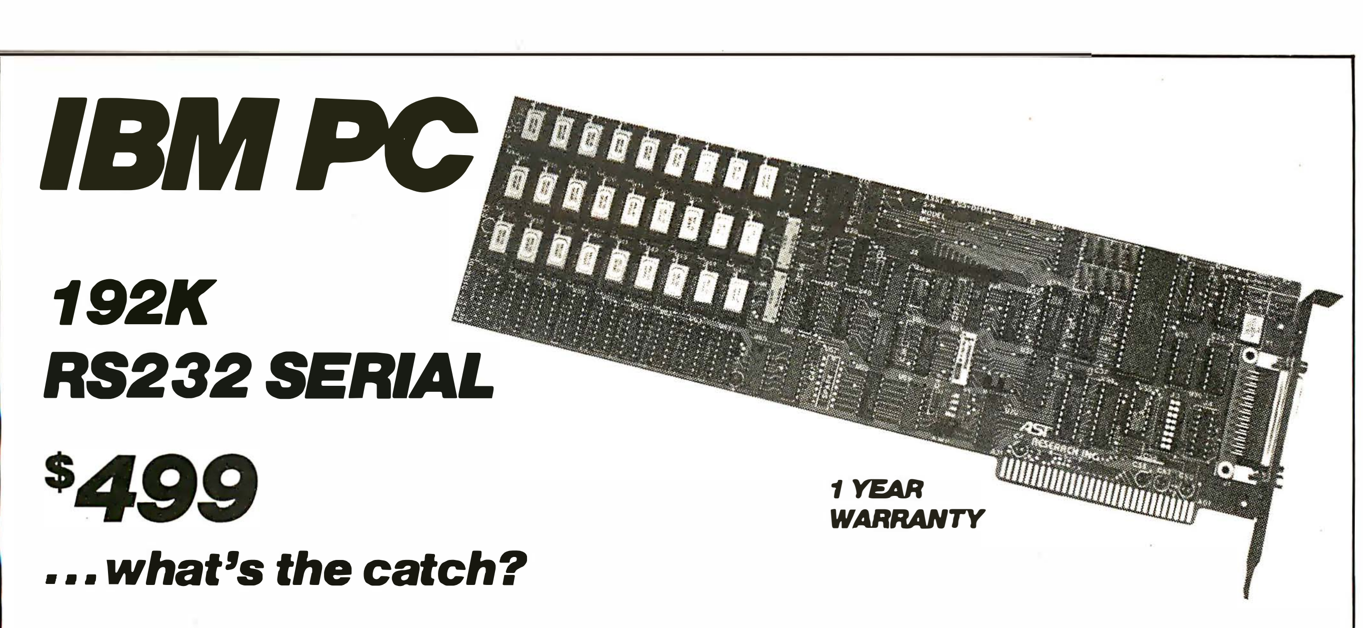
- *Remember that while you are docked at a starbase, you can view the galactic chart and set up for your next hyperspace jump. That way, when "transfer complete" appears on your screen, you can immediately enter F (Forward view) and then H (hyperspace). Not only does this save time, but you get to watch the repair ship flash by (and probably scare the dickens out of its crew).*
- *Zylon task forces vary in size, but the smallest ones always move toward starbases the fastest; wipe them out first.*
- *Zylons jump into hyperspace on time units ending with .00 and .50, so check the time when you're planning your next hyperjump—if the clock is between .40 and .49 or between .90 and .99, it's worth your while to wait and watch time—they will very likely move out from under you if you don't.*
- *As long as your subspace radio is working, you will get a message whenever a starbase is surrounded. Early in the game, when there are a lot of fast Zylon squadrons around, it's best to go to the starbase's aid immediately.*
- *If you know you can't save a surrounded starbase, admit defeat and go in and blow it up yourself as soon as you can (see the next section on how to hyperwarp directly to starbases). You'll be penalized, but not as much as if the Zylons had done it; and this way, they don't get to use the wreckage to build more ships.*

Saving Energy

- *If you want to, you can turn off shields, etc., to save energy during hyperwarps.*
- *You can usually hyperwarp directly to a starbase by centering the indicator on the attack-computer display as you enter the starbase's sector. This lets you "coast" right up to the base.*

Text box continued on page 390

IBM PC



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...what's the catch?

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IBM DIDN'T MAKE IT SIMPLE

Well that's good, because simple usually means limitations, and so far we have not found a lot of limitations. It is hard to pick IBM cards when you have only five slots. Now lets see. If you want graphics and color you buy one board. And if you want a printer port you buy another. Or you buy a monitor adapter and you get a printer port on the same board. When you want to add serial communication it's another board. Add some memory at 64k per board. Wait a minute. Thats two plus one, plus one, plus one more, minus one if you don't want graphics — HELP!! Your PC is now a mass of boards and you still want to do more. Not only that, but you now have spent so much money on boards you may have to compromise somewhere else in your system.

A QUICK SURVEY

We decided the answer was a board that could do several jobs and use a single slot. First we called IBM to find out what kinds of boards and accessories are sold in what percentages. Wrong question. You would have thought we had asked what was on the missing 18 minutes of the Watergate tapes, because that's what we got — a long silent pause. The official answer was "that information is not available to non-IBM people." So we started calling dealers and asking them. Turns out that about 85% of the systems they sell have the monitor board with the printer port. The next most popular item is the asynchronous serial board, and then memory. Almost all of the salesmen we talked to tried to tell us we didn't want IBM 64k memory boards, and they would be happy to sell any number of aftermarket boards for prices ranging from $795 to $1195. A.C. Nielsen would be proud.

HOW IT'S DONE

Land. Printed circuit area is called land. If you have enough land, and you are real clever in how you use it, you can "grow" everything you want on one board. In this case we have enough land to do all the popular things. First 192k. This combined with the 64k in the PC gives you 256k. Just the right number. Count 'em. Nine per row of 64k bit chips so you get parity checking. Our board comes standard with an RS232-C serial port. All of the good things like solder masking, silk screening of parts locations, and of course gold plated connectors are standard. Each board is tested and burned in.

For an additional $50 you can get a parallel printer port. On the little land we have left we are adding a real time clock which you can have for $50. You can put in your own row of chips to increase the memory to 256k, but we won't warranty your row of chips. For $100 we will add them to the board, test, burn in, and warranty them.

AN OFFER YOU SHOULDN'T REFUSE

One of the best things you can use the PC for is a spreadsheet program like Visicalc. That's how we figured out exactly how much this board cost us to build and how much to sell it for. Then we discovered Supercalc. All the things we liked about Visicalc are in it, and all the things we did not like are corrected. It addresses all the memory (256k), and in fact will address 512k if you have it. Now the offer. If you buy the package from us, the board and Supercalc, it will only cost you $675. Look around. You don't have to take our word for it. But you should. The offer is only good if you buy them both at the same time.

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Text box continued:

•If you can't swerve in time, it's best to blast incoming enemy rounds: photons cost you 10 mergs, but taking a hit costs 100 mergs (plus damage).

Battle Techniques

•Note that your fired photons never go above the horizontal crosshair on your screen, so it seems advisable to keep Zylon ships below the crosshair too.

•Any hits that you receive toward the center of your screen seem to do much more damage than those on the periphery.

Damaged Equipment

•Use the sector scanner only as a backup device for the times that your computer is out of commission. It takes too long to adjust your course by using the sector scanner; rather, learn to rely on the instruments and the attack-computer display.

•When your ion engines are damaged, note that the velocity indicator flickers between 0 and 12; if you then try to select a speed, the speed indicator flickers between 0 and 6. If you're going after a Zylon who damages your engines, don't touch the speed controls.

•Your hyperwarp engines can be used within a sector if your ion engines are damaged. Simply abort hyperwarp by selecting speed 0 when you get to where you want to go (you'll lose the speed advantage described above, and it'll cost 100 mergs to abort the hyperwarp).

Videosyncrasies or Things That Happen but Shouldn't

•The animation slows for several seconds after an explosion; it may speed up at an inopportune moment. The effect is that your ship responds slowly as you try to line up on a Zylon, then, all of a sudden, his ship zips in and fires very quickly.

•When looking through an aft view, always turn toward incoming enemy rounds to avoid being hit.

•At the higher difficulty levels, some enemy rounds may seem to go by but still score damage.

•The tracking computer is a handy tool; learn to use it, but watch out: if you destory a Zylon in front of you after he has fired, the tracking computer will switch to aft view and the enemy round will score—learn to swerve if this happens.

Further Fun

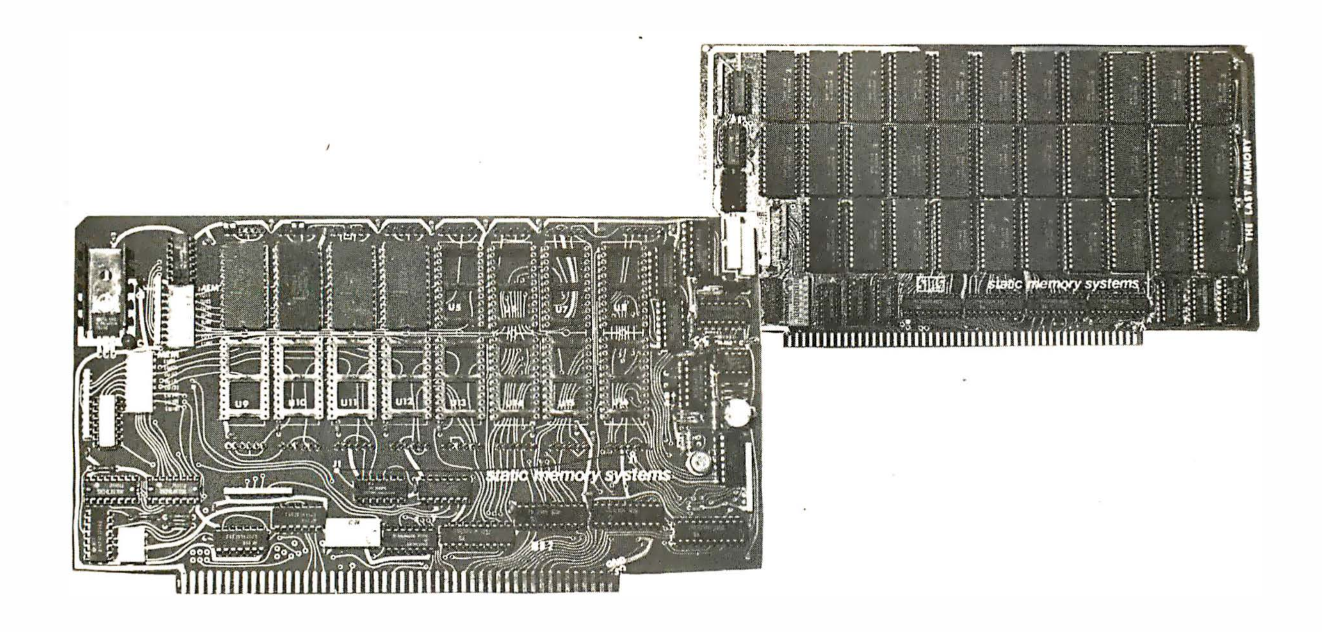
•It seems to help your cause if you call the Zylons by name. Suggestions are:

Vermin	*Zyloons*
Villains	*Zyklowns*
Nasties	*Zylarks*
Dastard	*Hey You!*

•If you think you're getting good at it, try playing Sudden Death (Warrior level with no shields).

Damn the photons! Full speed ahead! . . . **CPF**

TECHNOLOGY ADVANCES



THE LAST MEMORY™ is a high performance 64K memory module for 8 bit S100 systems. This board uses 16K byte-wide static RAM's which eliminate the timing and reliability problems associated with dynamic RAM boards. The 2K by 8 architecture of these RAM's allow high density and low power consumption, a characteristic not found in most static memories. This architecture also allows the use of 2716 type EPRPOM's in place of RAM IC's with no modification. As a result, this one board provides total system memory. **THE LAST MEMORY™** is available starting at less than $100.00

LASTING MEMORY™ is a combination EEPROM (Electrically Eraseable PROM)/EPROM/RAM memory module for 8 bit S100 systems. This board includes an onboard EEPROM programmer which programs and erases 2816/2815 type EEPROM's with normal memory write instructions - no special software is required. Erasing and writing may be performed one byte at a time - no need to start over to make simple changes. Programming may be performed in any socket - EEPROM's can be tested and used without moving them. EEPROM's, 2716 type EPROM's, or 16K byte-wide static RAM's may be located in any of the 16 memory sockets for a total of 32K bytes of memory. **LASTING MEMORY™** is available at $299.

The **VIB1™** is an intelligent I/O mapped CRT controller for use within S100 BUS (IEEE 696) systems. It incorporates all the video display capabilities of a stand-alone smart terminal. Some of its outstanding features include: 80 characters x 24 lines with an independant 25th line; full ASCII character set including control characters; graphics characters set; six visual attributes which can be used in combination; extensive screen editing and screen read capabilities. The **VIB1™** will be available in the 4th quarter 1982 at less than $300.

ideaLink™ is a high speed FSK modem which plugs into the S100 BUS (IEEE 696) and connects to a standard telephone in place of the handset. It is Bell 103/202 compatible offering both 300 Bps full duplex and 1200 Bps half duplex. All signal processing is performed digitally for long term reliability. **ideaLink™** will be available in the 4th quarter 1982 at less than $300.



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Text continued from page 385:

from hits from enemy photons and using the twin ion engines. By far the most important of these is avoiding being hit by enemy photons. Each photon hit costs 100 mergs (energy units) and causes damage. Damage not only reduces your chances of survival, but certain kinds of damage will mean an unplanned trip to the nearest starbase for repairs. This extra trip could cost 300 to 800 mergs or more. Eight hundred mergs is equivalent to about eight final-score points, or the difference between ranks of Star Commander 1 and Star Commander 2.

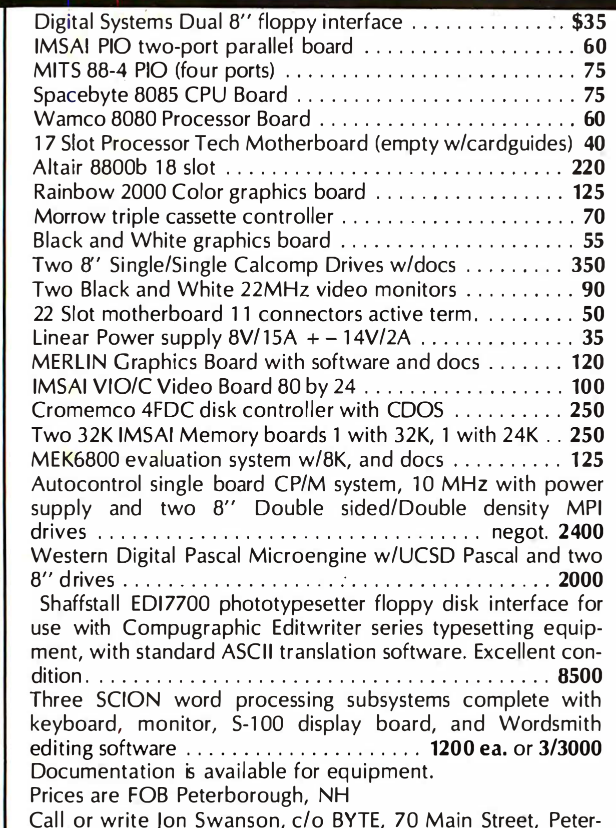
The ion engines should seldom be needed in the enemy sector. As your ship comes out of hyperwarp and coasts to a stop, three different types of enemy movements will be found: ships with no movement, fast-moving ships that will seem to approach you but then retreat, and ships coming on at full-speed attack. Notice that ships within 120 metrons (distance units) will always attack, become visible, and be within photon range.

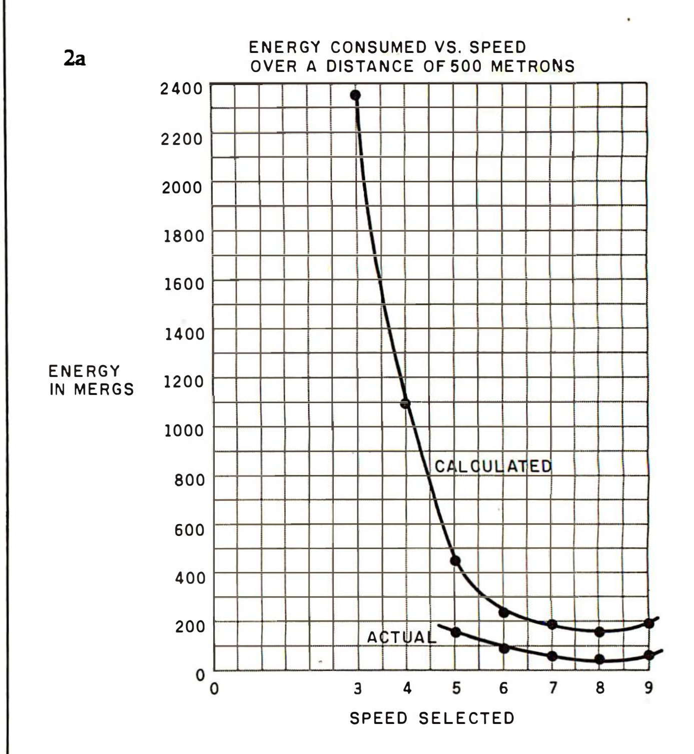
Don't trust your tracking computer to lock on to the *nearest* enemy vessel. If you are not immediately under attack when entering a sector, press M (the manual-tracking key) to avoid nasty surprises. If a ship is coming on at full speed, just wait for it. When a ship seems to be coming in for an attack, but then takes off in some other direction, don't chase it because that's the sucker move. Scan the sector for another ship to attack. If you have the time and patience and are willing to wait, the enemy will eventually come to you. (But don't forget that your starbase is under attack while you are waiting.) Early in the game at the Commander Level, you cannot afford to wait.

Contrary to what the user's manual tells you, speed 6 is not the most efficient way to use your ion engines. Energy requirements for shields, computers, and life-support systems must be accounted for during the journey. According to the manual, the energy drain for these systems is 2.75 mergs/centron (energy units per time unit). Although my tests show a lower energy consumption, the most efficient speed is actually 8 not 6. Figure 2 shows calculated and measured energy consumed for distances of 500 and 900 metrons. The calculated values are based on information taken from the user's manual. In either case, there is little difference in energy used for speeds above 7.

Engaging the Enemy

As you come out of hyperwarp and coast to a stop, you will often find yourself overrunning an enemy ship and being fired on before you are ready to defend yourself. Try this! As the ship comes within about 150 to 200 metrons, throw your ship into a hard turn in either direction. Hold the turn until the enemy has passed all the





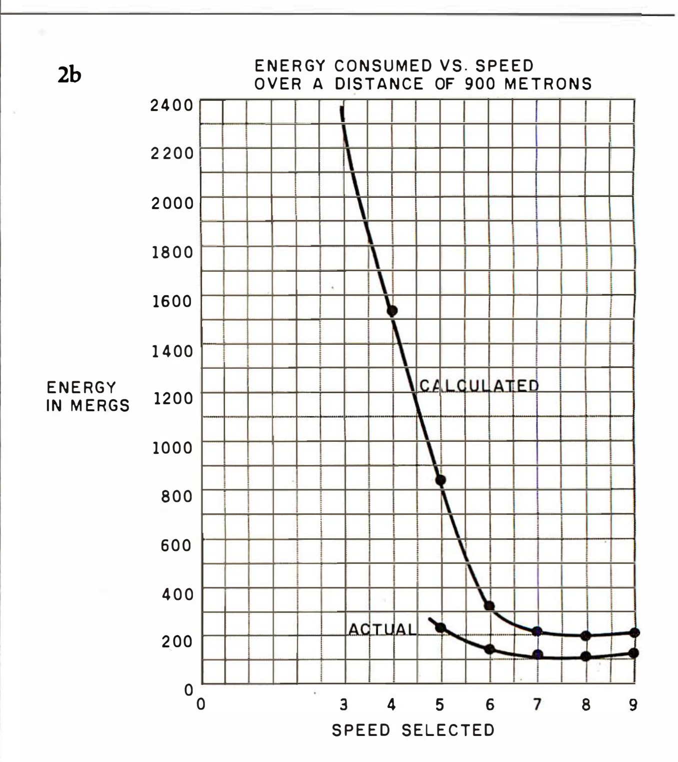


Figure 2: *Energy expended for ion engine use. Contrary to the figures in the user's manual, selected-speed 8 is most efficient when other systems are also drawing energy. Figure 2a shows the energy expended at a variety of speeds over 500 metrons. Figure 2b shows the corresponding values for a distance of 900 metrons.*

Priority	Name	If Damaged	If Destroyed
1	shields	hyperwarp at once	hyperwarp at once
2	photons	finish sector if even odds	hyperwarp at once
3	computer and sector scan	finish sector if even odds	hyperwarp at once
4	subspace radio	———	finish sector
5	computer	continue	finish sector
6	engines	continue	continue
7	sector scan	continue	continue

Table 1: *Damage priorities determine when to leave for repairs immediately. In the chart, "finish sector" means wait until you have disposed of all the Zylons in the sector before hyperwarping to a starbase; "finish sector if even odds" means go for repairs immediately unless there is only one Zylon in the sector. If more than one piece of equipment is damaged, follow instructions for the highest-priority item.*

way behind you and is coming around the front again. Watch your instruments. By this time the screen will have stopped flashing, and you will be ready to fight with no distractions.

As the enemy approaches from the front, maneuver your joystick to keep him off to the side and low. The idea is, of course, to avoid photon hits and damage as he approaches. When the enemy is about 20 metrons away, swing him into your sights and blow him away. Conserve your photons—they cost energy too. Don't let the Zylon get much closer than 20 metrons before using this maneuver, because he just might zip around behind you. If two ships are attacking from the front at once, concentrate on the one closer to the center of the screen.

A word about attacks from the rear: for several weeks I tried to handle aft attacks without much success. If you can handle a frontal attack one second and an aft barrage the next (with all your joystick movements reversed), that's great; but I've found that you can still reach Star Commander 1 without mastering the aft attack. To bring an aft-attacking enemy to the front, just throw your ship into a hard spin and he will wind up in front of you. You will notice that you are almost never hit while in a spin.

The toughest situation is simultaneous front and aft attacks. You can quickly turn off autotracking (press T) to concentrate only on the front. I've already suggested how to handle frontal attacks, but in this situation throw in a small amount of back and forth joystick movement. This hurts the aim of the aft attacker.

Necessary Capabilities

How do you know when to cut and run? For some kinds of damage, there is no doubt. Some systems, however, are more important than others, so the decision is not clear cut. Table 1 is presented for your use as a guide only. Many other damage combinations are possible and are left to your judgment, skill level, and the game situation. To help explain the chart, here are some examples:

- In a case where your photons are damaged, finish the sector if only one enemy ship remains and then go to the nearest starbase for repairs. If you are outnumbered, leave the sector immediately.
- In a case where your computer and the sector-scan systems are damaged and your ion engines are destroyed, finish the sector if you are faced with only one Zylon, then go for repairs.

A final hint: your subspace radio is much more important early in the game than it is later when enemy ship movements are not as threatening.

What I've described here is just about all I know about Star Raider. I hope these suggestions will be helpful to your pursuit of new and better ranking and many more hours of enjoyment. ■

Model III A to D Revisited

Build this simple and inexpensive analog-to-digital converter.

William Barden Jr.
28122 Orsola
Mission Viejo, CA 92692

In an earlier article in this series (January 1982 BYTE, page 160) I described a joystick controller for the Model III that was also an analog-to-digital converter (ADC). In this article, I'll show you a much neater implementation of an ADC—one that uses only three chips and can be hooked directly to the cassette port of the Model III, eliminating a great deal of wire-wrapping and connector preparation. In fact, you can use this ADC with the existing cassette cable that plugs into the 5-pin DIN jack on the back of the Model III.

This ADC is also a little bit better than the earlier version. It's exactly 1 bit better: it will convert an analog voltage to 7-bit resolution, instead of 6 bits. In addition, this ADC is extremely accurate, down to about 20 millivolts (mV) for a 2.5 volt (V) range. In fact, if you buy this circuit tonight, I can make you a special deal. . . .

One disadvantage, however, is that this ADC will allow only a half dozen or so samples per second. This is no detriment, though, if you are monitoring slowly changing real-world events such as temperature, pressure, or ambient light.

About the Author
William Barden Jr. has written many books on microcomputer programming and design, including Microcomputer Math.

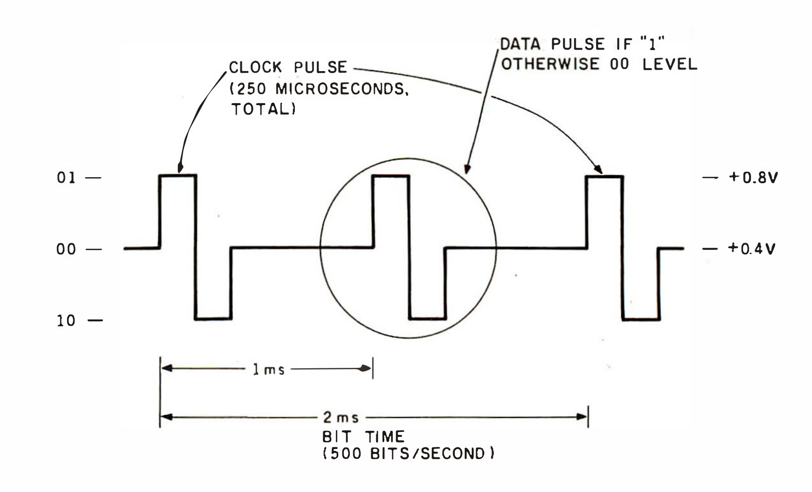


Figure 1: *The 500-bps tape format of the Model III (and Model I) uses a clock pulse and data pulse for each data bit. The data pulse is absent for a 0 bit.*

Model III Cassette Port

I've described the Model III cassette port in other articles, but it probably won't hurt to review the circuits rapidly.

The Model III is capable of writing data on cassette tape in either 500- or 1500-bit-per-second (bps) format. The same circuitry is used for 500- and 1500-bps output, but the resultant tape formats are different.

The 500-bps tape format is shown in figure 1. Each bit time is made up of a leading clock pulse followed by a second pulse for a 1 or no pulse for a 0. The duration of each pulse is about 250 microseconds (μs), top and bottom.

The 1500-bps tape format is shown in figure 2. Here, the format is that of "frequency-shift keying," one frequency for a 0 and a second frequency for a 1 bit.

Both formats use software that drives a simple circuit to produce three voltage levels (only the two ex-

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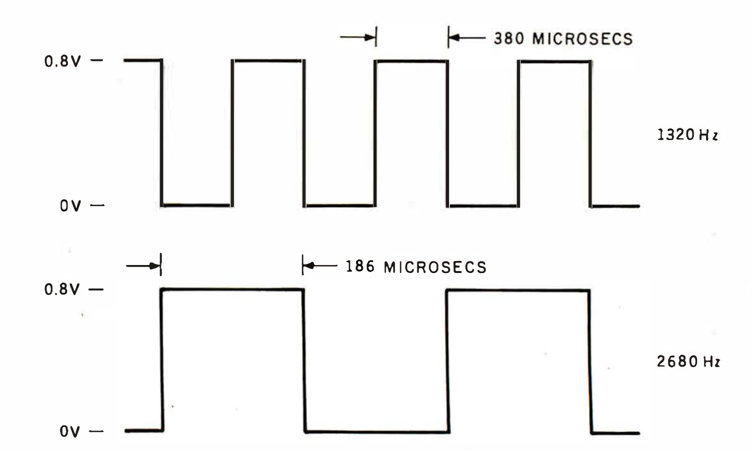


Figure 2: *The 1500-bps tape format for the Model III uses a frequency-shift-keying technique. Two frequencies are used to represent 0s or 1s.*

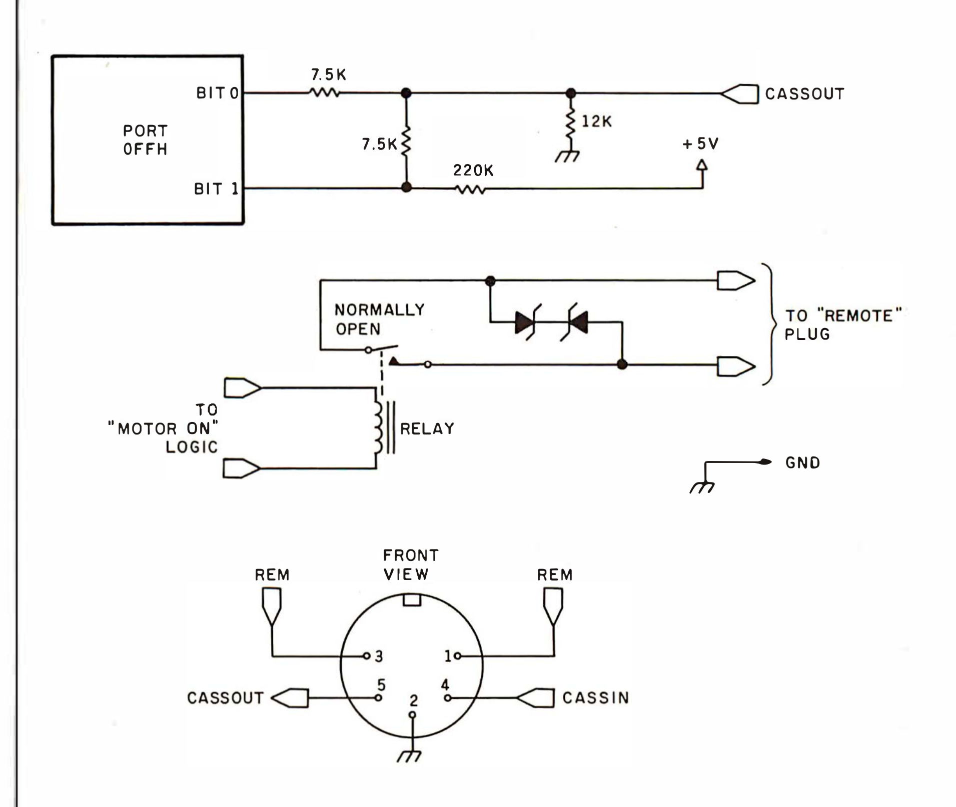


Figure 3: *The Model III cassette output logic uses a simple two-bit latch to generate three analog levels that are used to write to cassette tape.*

tremes are used for 1500 bps): 0 V, .46 V, and .85 V. (See figure 3.) The levels are produced by outputs to a 2-bit latch with input/output port address hexadecimal FF. The latch simply records the two least significant bits sent to I/O address FF. If a binary *xxxxxx*00 is output, a .46-V level is produced. Binary *xxxxxx*01 produces a .85-V level, and *xxxxxx*10 produces a 0-V level (*x* indicates that the value of a particular digit is insignificant).

Toggling the latch bits in an assembly-language program can produce any square wave output of any frequency, up to the limits of the electronics in the cassette circuitry. Unfortunately, this action must be in assembly language, by the Z80 instruction OUT (0FFH), because

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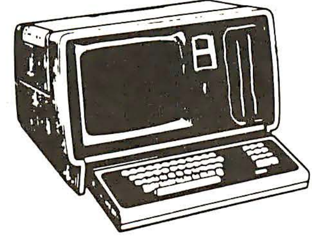
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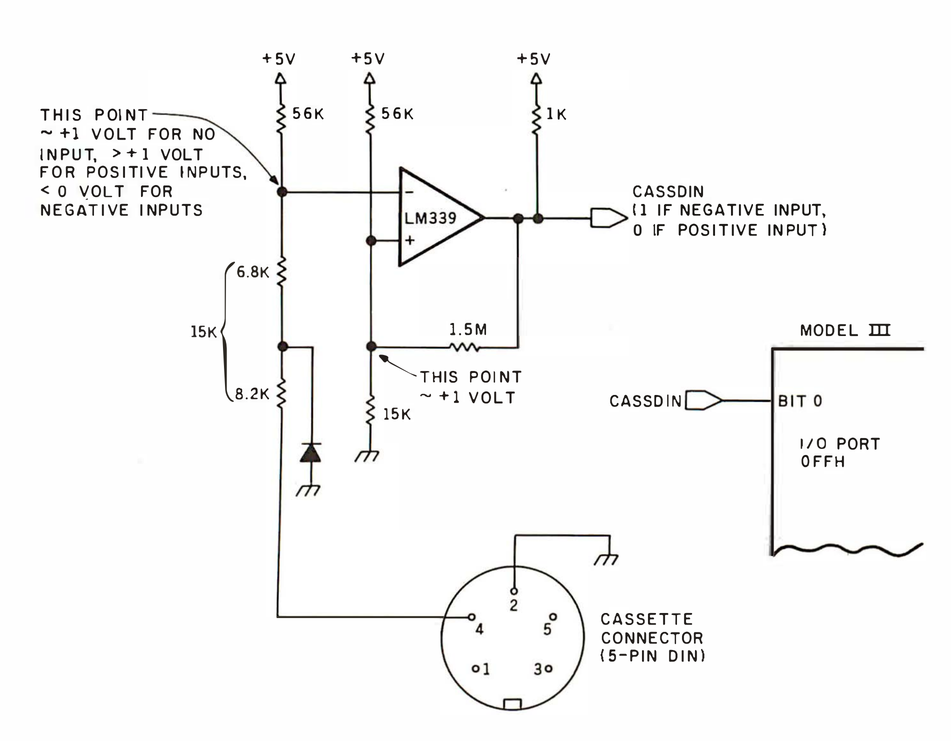


Figure 4: *The Model III cassette input logic for 1500 bps uses a zero-crossing detector to detect when the input waveform goes negative. The output of the comparator goes to bit 0 of input port hexadecimal FF.*

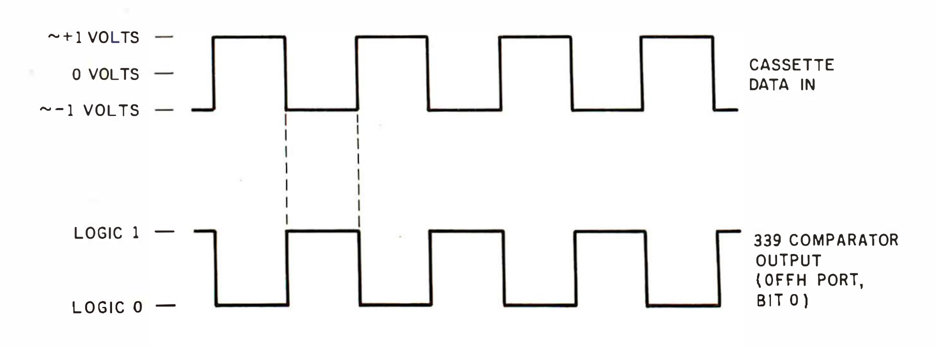


Figure 5: *The cassette input waveform is a nominal 2 V peak to peak. The resulting output from the comparator is an inverted duplicate.*

BASIC is much too slow to achieve the relatively short pulses required. A BASIC OUT (255) performs the same function at much slower speeds.

The Model III has two separate circuits for reading cassette data, one for 500 bps and one for 1500 bps. The 500-bps circuit works by essentially rectifying the incoming pulse and then looking for the DC level from the rectification. (It's very similar to the Model I circuitry.) The 1500-bps circuit uses a much different approach, as shown in figure 4.

The circuit in figure 4 is a zero-crossing detector that looks for negative pulses. The output of the LM339 comparator is a 0 with no input or a positive pulse, but it switches to a 1 with the negative-going edge of the pulse. It remains a 1 until the pulse switches back to a positive level, as shown in figure 5.

The CASSDIN (Cassette Data In) bit is read by performing the Z80 instruction IN (0FFH) and checking bit 0, the 1500-bps cassette bit (bit 7 is the 500-bps bit). Again, assembly language allows you to sample the CASSDIN bit thousands of times per second. A BASIC INP(255) will also perform the same function but at much slower speeds.

It appears, then, that you can easily output square waves and read in a voltage level. How is this going to help you implement an analog-to-digital converter?

New for '82!

Whilst paging through the ubiquitous Radio Shack catalog, I happened to see an ADC chip called the TL507C. At first glance it didn't appear very imposing (it's an 8-pin device and rather ugly, as semiconductors go), but it turned out to be a diamond in the Shack.

The internal workings of the TL507C are shown in figure 6. It uses a ramp method of A-to-D conversion and is made up of a 7-bit counter, a few gates, and two comparators.

The counter is the heart of the chip. It simply counts from 127 through 0 and repeats this cycle continuously. The counter may be reset at any time by bringing up the RESET input to a high (V_{CC}) level. If the RESET is held at ground, the counter is powered up to some indeterminate state but settles into the 128-bit count cycle within 128 counts.

The 7 counter bits are connected to "binary-weighted" resistors. The resistors are actually a digital-to-analog converter (DAC) resistor "ladder" network. Each output of the counter produces a voltage that is twice as great as the preceding stage. The analog voltages are added together in the operational amplifier to produce the analog voltage corresponding to the value in the 7 bits of the counter. As the counter counts from 127 through 0, a *ramp* of voltage is generated, with each step of the ramp changing the output voltage by 1/128 of full scale. (See figure 7.)

The TL507C is designed so that one of two voltages may be used for power. The V_{CC1} input is the "normal" power supply input and may range from +5 to +6 V DC. The V_{CC2} input may be used instead; in that case, the power supply may be





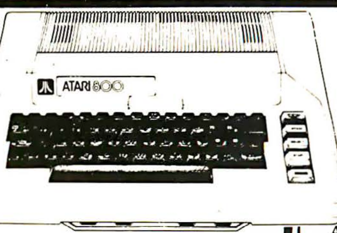
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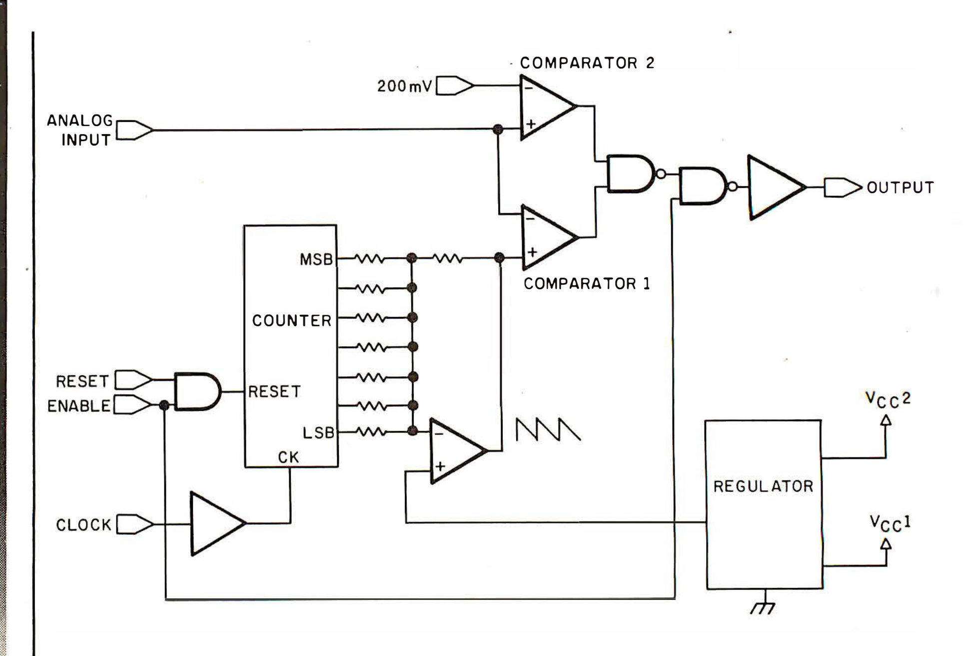


Figure 6: *The TL507C chip is an analog-to-digital converter (ADC) that compares an analog input to an internally generated ramp voltage that steps through the allowable range of input voltages. The comparator output goes true when the ramp voltage falls beneath the analog input voltage.*

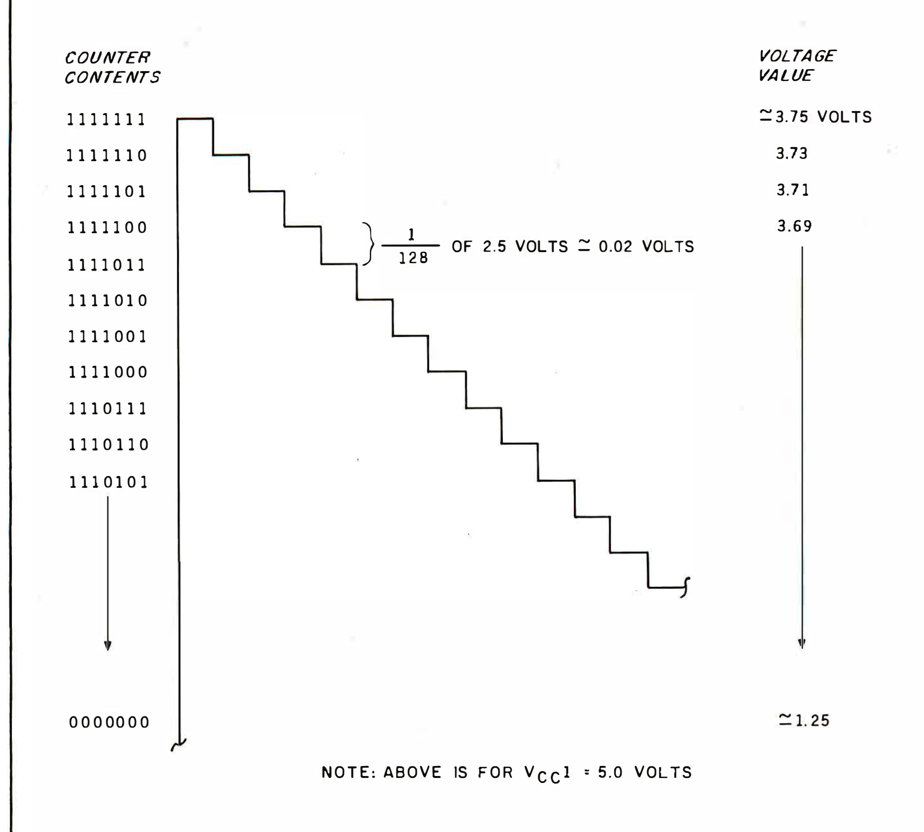


Figure 7: *The TL507C generates a ramp of voltages from a 7-bit counter and a "weighted" resistor network. The smallest increment is 1/128 of the total voltage range for the ramp.*



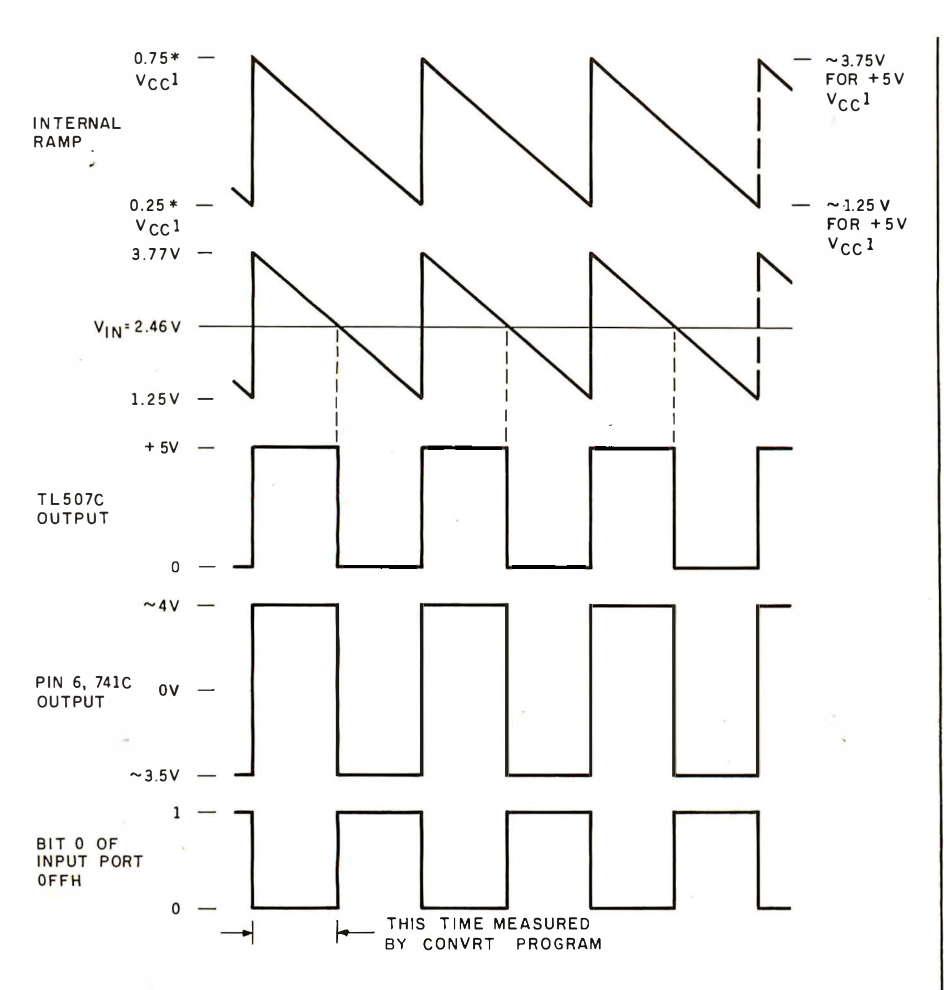


Figure 8: *The analog-to-digital conversion is performed externally to the TL507C by measuring the duty cycle of the chip's waveform output. The duty cycle changes according to the analog input voltage.*

"unregulated" and may range from 8 to 16 V. In the design that I've used here, I've chosen to use V_{CC1} and not V_{CC2}; the V_{CC2} input is simply not connected.

The ramp voltage generated during a count cycle ranges from .75 of V_{CC1} through .25 of V_{CC1}. This range of voltages is accurately controlled by the TL507C. Therefore, with a V_{CC1} of +5 V, the ramp will range from +3.75 V through +1.25 V, as shown in figure 8.

The ramp output goes to comparator 1, which compares the analog input voltage and the ramp voltage. The output of the comparator is a 0 or 1 depending upon whether the analog input voltage is greater or less than the ramp voltage, respectively. For any constant analog input voltage, the comparator output will approximate a square wave as shown in the figure (labeled "TL507C Output"). As the ramp repeats continuously (with a constant stream of clock pulses), the *duty cycle* (relationship of "on" time to total cycle time) will vary with the analog input voltage. With a large analog input voltage, the comparator output will quickly go to 0, while with a small analog input voltage, the comparator output will reach 0 near the end of the ramp.

The width of an "on" pulse is therefore directly proportional to the analog input voltage. If this pulse width can be measured, the analog input voltage can be determined easily. This approach would be used in a strictly hardware implementation of the TL507C circuit (e.g., measurement of the duty cycle of the output waveform).

An alternative approach is to increase the ramp voltage by outputting a single clock pulse, comparing the

ANALOG INPUT CONDITION	ENABLE	OUTPUT
X	L†	H
$V_I < 200$ mV	H	L
$V_{ramp} > V_I > 200$ mV	H	H
$V_I > V_{ramp}$	H	L

† Low level on enable also inhibits the reset function.
H = high level, L = low level, X = irrelevant

Table 1: *My implementation of the ADC uses the last two function table entries. ENABLE is always H(igh), and the analog input voltage is not normally below .25 × V_{CC}.*

comparator output, pulsing the clock again, and so forth until the comparator output changes. If you know how many clock pulses you have output, you know the duty cycle. The total number of clock pulses in a ramp cycle is 128, and the duty cycle will be as follows:

duty cycle =
number of pulses before comparator switch/128 × 10

The scheme I'll use in my implementation of the ADC is to control the clock-pulse output and test the comparator output.

Getting back to the TL507C internal diagram, here are a few remaining points to consider. The ADC is set up so that an analog input of less than 200 mV disables the output. This level of voltage is considered to be an invalid input signal. Second, if the ENABLE input is grounded, the device OUTPUT signal will remain high (1). I'll keep the ENABLE input permanently active by tying it to V_{CC}.

The truth table for the TL507C is shown in table 1. Under normal circumstances, the only conditions you'll be working with would be the last two entries, for analog input voltages greater than 25% and less than 75% of V_{CC}.

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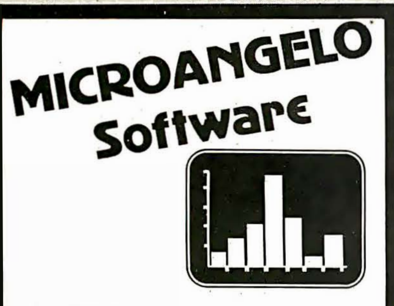
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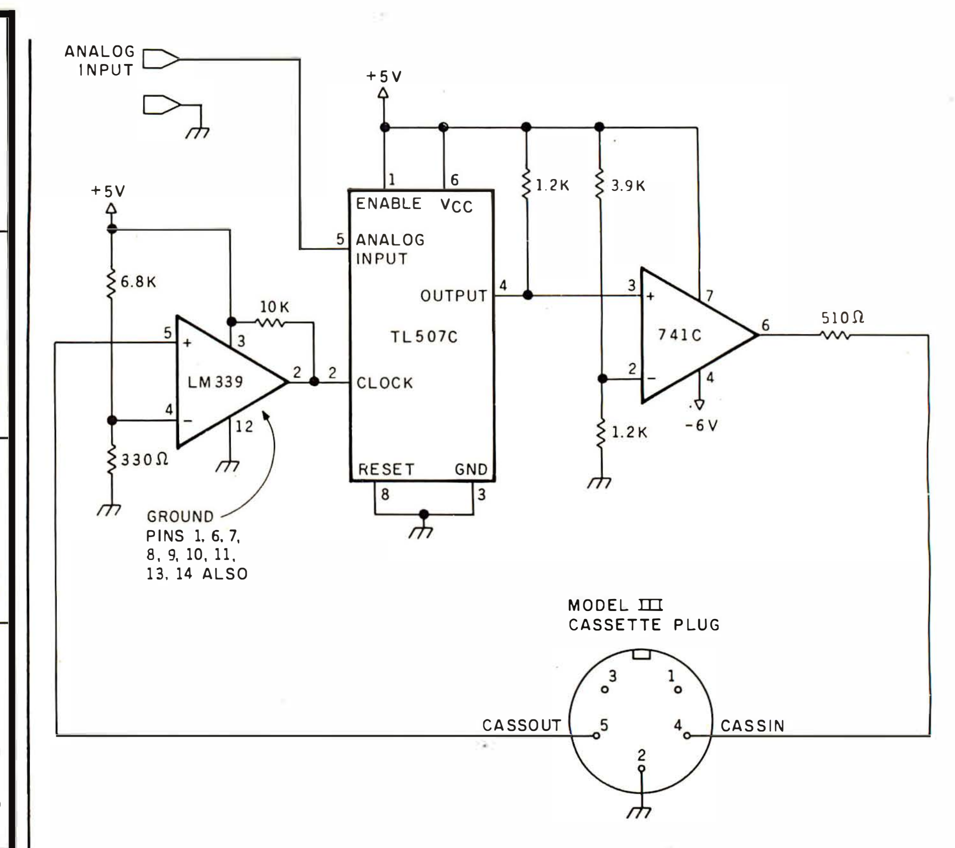


Figure 9: *Three chips make up the ADC circuit that connects to the cassette jack of the Model III. The TL507C is the heart of the ADC, and the remaining chips perform level conversion.*

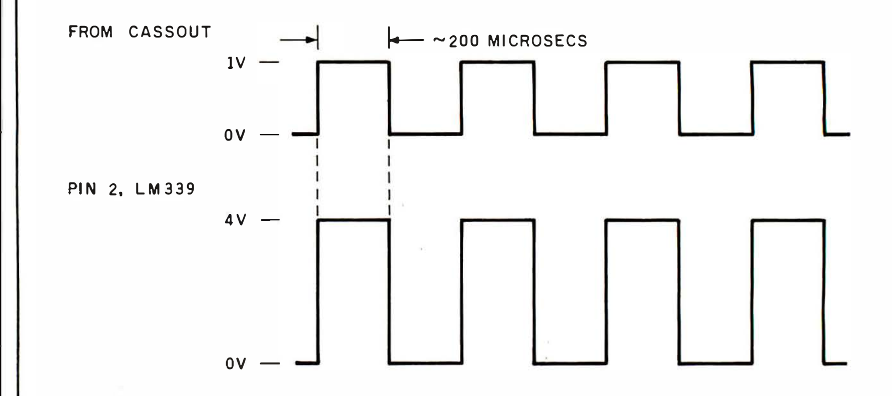


Figure 10: *The LM339 comparator changes the 1-V peak-to-peak cassette output waveform to a TL507C-compatible level.*

The A-to-D Circuit

The circuit for the Model III ADC is shown in figure 9. The heart of it, of course, is the TL507C. The LM339 comparator is used for level conversion of the Model III cassette output signal, while the 741C is used for level conversion to a Model III-compatible cassette input signal.

The CASSOUT signal. The clock input to the TL507C is derived from the Model III cassette output. This clock input would normally be the signal that goes to the AUX input of the cassette recorder during a write/tape operation. The CASSOUT signal is shown in figure 10. It is a 0- to 1-V square wave.

The clock input to the TL507C must be at least 2.5 V, which calls for

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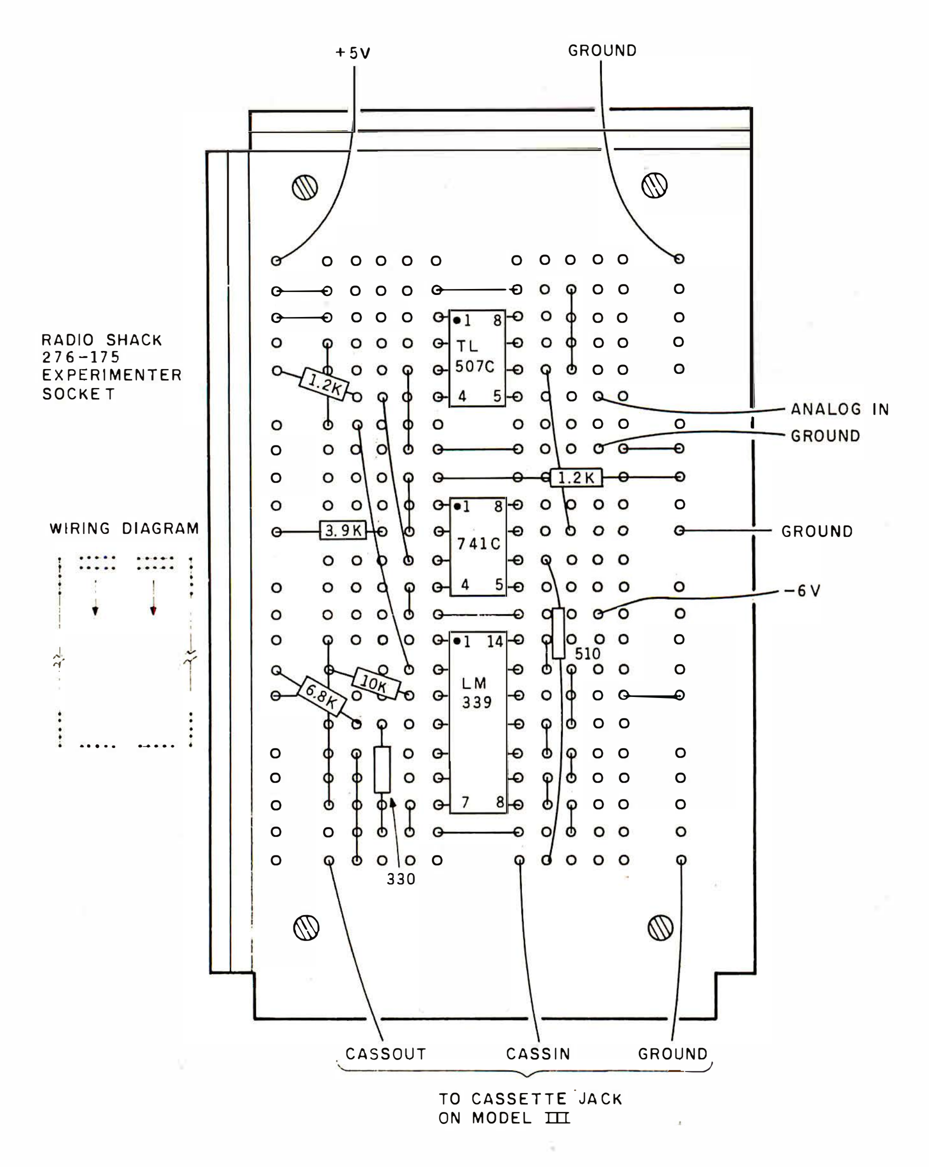


Figure 11: *The simple and inexpensive ADC is constructed on a Radio Shack 276-175 prototype board.*

some level conversion of the CASSOUT signal. The LM339 accomplishes this by comparing the CASSOUT signal to a voltage of about .25 V at the junction of the 6.8k-ohm and 330-ohm resistors. The output of the LM339 is shown in the figure; it is identical to the CASSOUT signal except that it has a greater voltage swing.

The CASSOUT signal is the clock for the TL507C. Each pulse will be (arbitrarily) set to a width of about 200 μs. The counter in the TL507C changes on the negative-going portion of the clock pulse. A complete ramp will require 128 clock periods.

The CASSIN signal. The cassette input circuitry in the Model III responds to a negative voltage level. The output voltage of the "open-collector" output line from the TL507C swings from about 0 V to about +5 V and must therefore be converted to a waveform that swings both positively and negatively. The 741C accomplishes this by comparing the output voltage with 1.2 V at the junction of the 3.9k-ohm and 1.2k-ohm resistors. The output of the 741C follows the output of the TL507C as shown in figure 8.

Other connections. The ENABLE input of the TL507C is tied to +5 V, making the chip always active. V_{CC2} is not connected. RESET is tied to ground. The counter will be at some meaningless value when power is first applied but thereafter will repeat modulus 128. The ANALOG INPUT is tied to ground.

Constructing the ADC

The ADC circuit was built up on a Radio Shack 276-175 prototype board shown in figure 11. The prototype board has two bus columns for power and ground on the left and right sides of the board. There are two sets of 23 rows used for connecting integrated circuits (ICs).

The figure is meant as a general guide for interconnections; use the logic diagram of figure 9 as the definitive circuit. Solid lines in the construction figure represent solid bus wires; these can be routed under or over components. Note the keying of the IC chips. Pin 1 on all chips is at the upper left corner.

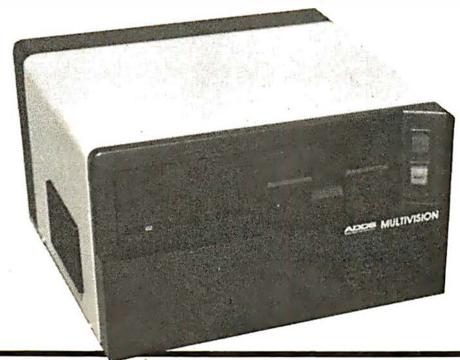
After the board has been wired up, recheck the wiring and prepare the power cables. The two wires on top go to a +5 V power supply. Radio Shack has an inexpensive +5 V kit (277-125) that you can use for this purpose.

The −6 V wires on the right side should be connected to the −6 V supply for the 741C. You may substitute a +6 V battery in place of a large power supply with no problem as the 741C will draw negligible amounts of current. The positive lead to the battery or power supply attaches to the ground bus of the prototype board.

The three leads on the bottom go to the cassette-input jack on the Model III. The proper pin numbering is shown in figure 9 and has been discussed in a previous article (see "A Po(r)tpourri of Ideas" in the April 1982 BYTE issue, page 158). For testing purposes, simply clip test leads to the existing Model III cassette cable as shown in figure 12.

The two leads for the analog-input signal connect to the voltage to be measured. A simple voltage divider, which uses one 10k-ohm potentiometer and a 10k-ohm resistor, is shown in figure 13.

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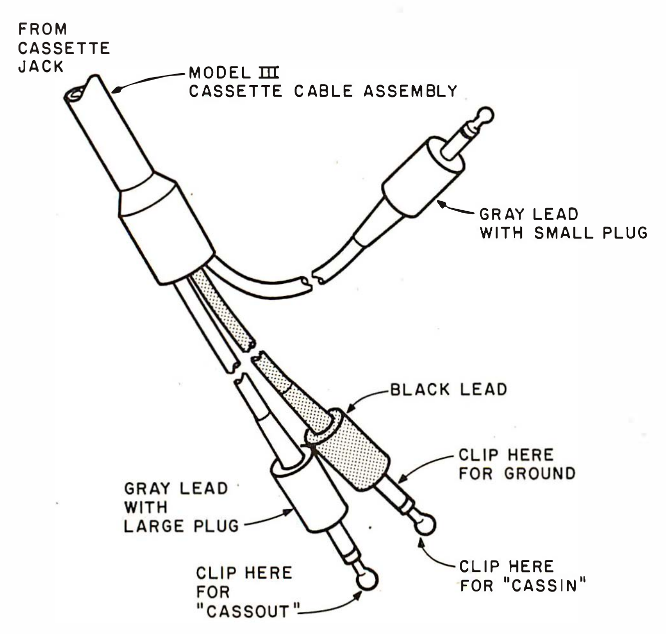


Figure 12: *The existing cassette cable for the Model III may be used to connect the ADC to the computer system. Three clip leads connect all signals.*

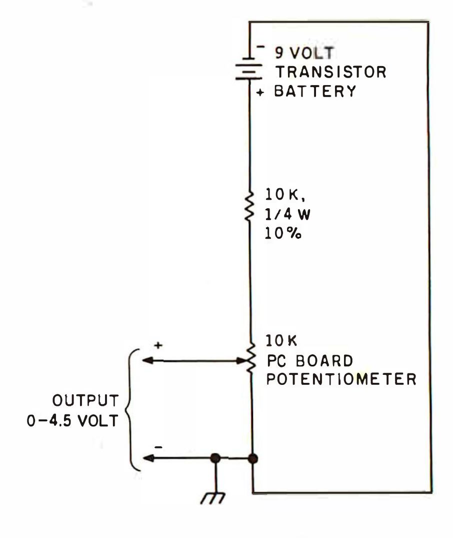


Figure 13: *The ADC may be tested by a simple voltage divider made from a 9-V transistor battery, a 10k-ohm resistor, and a 10k-ohm printed-circuit-board potentiometer.*

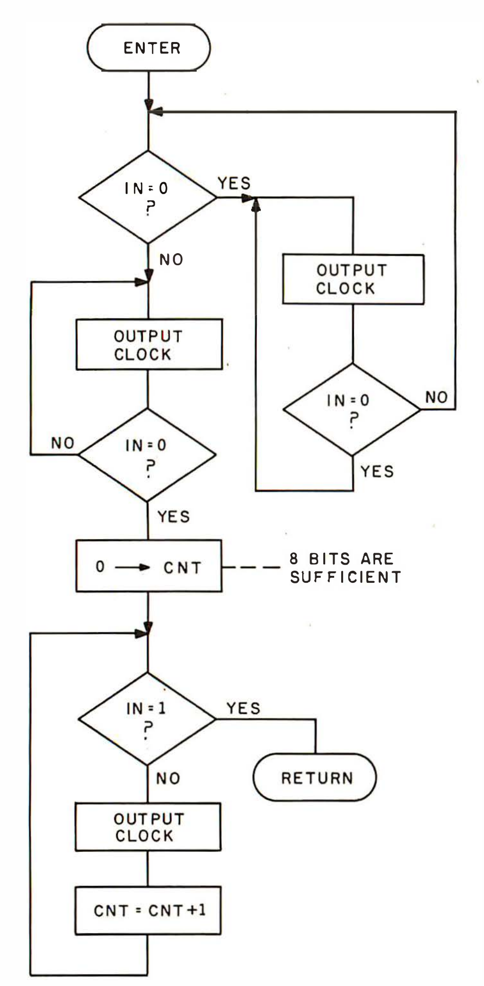


Figure 14: *The ADC algorithm is straightforward. Starting from a known condition, the cassette input is sampled and the clock pulses are counted until the analog input voltage falls below the ramp voltage.*

The Software

The flowchart in figure 14 shows the basic scheme for measuring the duty cycle by counting clock pulses. The CASSIN signal is read from bit 0 of I/O port hexadecimal FF. This bit is a 1 when the analog input voltage is higher than the ramp voltage.

If the input is a 0 initially, the ramp voltage is higher than the analog input voltage. In this case, clock pulses are output (via CASSOUT) until the input bit goes to a 1 (i.e., the ramp voltage is lower than the analog input voltage).

If the input is a 1, clock pulses are output until the ramp voltage rises above the analog input. At this point a count is set to 0. The maximum count will be 128, which can be held in one byte.

Now, clock pulses are output until CASSIN goes to 1. The count is incremented for each clock-pulse output. When CASSIN goes to 1, the ramp voltage has fallen below the analog input voltage.

This algorithm is implemented in the assembly-language program shown in listing 1. Three subroutines are used: TSTIN, OUTCLK, and DELAY.

DELAY simply causes a pause for a fixed amount of time, about 200 μs. It's called by OUTCLK to create a fixed-width clock pulse of 200 μs.

OUTCLK outputs one complete clock cycle to CASSOUT. The cassette toggle is first set one way by outputting a 2 to port hexadecimal FF. DELAY is then called. Next, the cassette toggle is set to the opposing voltage level by an output of 1. DELAY is called again.

The TSTIN subroutine is called by the main CONVRT program to test the state of the CASSIN line. The state of CASSIN is returned in the Z flag; Z is set (Z) if CASSIN is 0 or reset (NZ) if CASSIN is 1.

TSTIN also tests a "time-out" count in the DE register pair. The count is incremented; after 65,536 times, it will recycle to 0. When that occurs, TSTIN resets the stack and returns control to the calling (BASIC) program. Time-out occurs when CASSIN does not change state within a reasonable amount of time, and it is indicated by returning a count of −1.

The main driver portion of CONVRT implements the logic shown in the flowchart by calling TSTIN and OUTCLK. At the end of CONVRT, the count of clock pulses is held in the HL register pair and returned to BASIC by the standard return of "JP 0A9AH," which returns the HL register contents to a BASIC variable.

The assembly-language version of

Listing 1: *The A-to-D conversion program for the Model III, which implements the algorithm for measuring the duty cycle by counting clock pulses.*

```
7F00                        ORG     7F00H           ;CHANGE THIS AS REQD
                ;*****************************************************
                ;* A TO D CONVERSION PROGRAM FOR MODEL III           *
                ;*      INPUT: NONE                                  *
                ;*      OUTPUT:(HL)=CONVERSION COUNT OR -1 IF TIME OUT *
                ;*****************************************************
7F00 110000     CONVRT      LD      DE,0            ;TIME OUT COUNT
7F03 CD2B7F     CON005      CALL    TSTIN           ;LOOK FOR 1
7F06 200A                   JR      NZ,CON020       ;GO IF 1
7F08 CD3B7F     CON010      CALL    OUTCLK            ;0, WAIT 'TIL 1
7F0B CD2B7F                 CALL    TSTIN             ;TEST
7F0E 28F8                   JR      Z,CON010          ;GO IF STILL 0
7F10 18F1                   JR      CON005            ;RESTART
7F12 CD3B7F     CON020      CALL    OUTCLK            ;NOW LOOK FOR 0
7F15 CD2B7F                 CALL    TSTIN             ;TEST
7F18 20F8                   JR      NZ,CON020         ;GO IF STILL 1
7F1A 210000                 LD      HL,0            ;INITIALIZE CONVERT CNT
7F1D CD2B7F     CON030      CALL    TSTIN             ;NOW LOOP 'TIL 1
7F20 2006                   JR      NZ,CON090         ;GO IF 1
7F22 CD3B7F                 CALL    OUTCLK            ;PULSE
7F25 23                     INC     HL                ;BUMP COUNT
7F26 18F5                   JR      CON030            ;TRY AGAIN
7F28 C39A0A     CON090      JP      0A9AH           ;RETURN WITH ARG
7F2B 13         TSTIN       INC     DE              ;BUMP TIME OUT CNT
7F2C 7A                     LD      A,D             ;TEST FOR DE=0
7F2D B3                     OR      E
7F2E 2006                   JR      NZ,TST010       ;GO IF NO TIME OUT
7F30 21FFFF                 LD      HL,-1           ;SET ERROR FLAG
7F33 D1                     POP     DE              ;RESET STACK
7F34 18F2                   JR      CON090          ;RETURN
7F36 DBFF       TST010      IN      A,(0FFH)        ;READ CASS IN
7F38 E601                   AND     1               ;GET 1500 BAUD BIT
7F3A C9                     RET                     ;RETURN
7F3B 3E02       OUTCLK      LD      A,2             ;ONE WAY
7F3D D3FF                   OUT     (0FFH),A        ;OUTPUT
7F3F CD4A7F                 CALL    DELAY           ;DELAY ABOUT 200 MICS
7F42 3E01                   LD      A,1             ;OPPOSITE WAY
7F44 D3FF                   OUT     (0FFH),A        ;OUTPUT
7F46 CD4A7F                 CALL    DELAY           ;DELAY 200 MICS
7F49 C9                     RET                     ;RETURN
7F4A 0619       DELAY       LD      B,25            ;ABOUT 200 MICS
7F4C 10FE       DEL010      DJNZ    DEL010
7F4E C9                     RET                     ;RETURN
0000                        END
00000 Total errors
```

CONVRT executes at location hexadecimal 7F00. Listing 2 shows a BASIC driver program that calls CONVRT and also incorporates the machine-language code of CONVRT as a series of DATA statement values. The code is moved to the hexadecimal 7F00 area before execution of the BASIC program.

The BASIC driver for CONVRT converts the count returned from CONVRT to a voltage level, predicated upon a +5 V supply for V_{CC}. The iteration count is displayed in the middle of the screen along with the voltage value.

When V_{CC} is exactly +5 V, the allowable analog input can be +1.25 V through +3.75 V, for a total range of 2.5 V. Because there are 128 steps, each step represents 2.5/128 V, or about 0.01953 V. The actual voltage read from the analog input is expressed as:

$$V=(+3.75)-(CNT-1)*0.01953$$

and this value is calculated and displayed on the screen.

Using the ADC

Connect all power leads to the ADC and turn on the +5 V and −6 V DC. Make the obvious "smoke tests"; none of the chips should feel hot to the touch.

Connect a voltage source to the

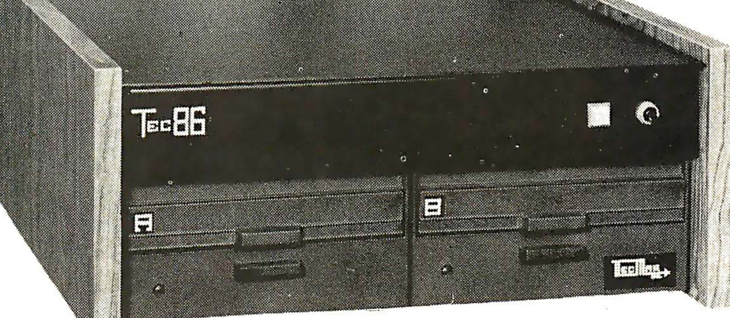
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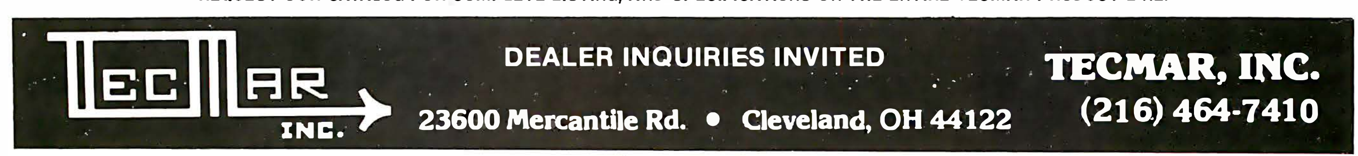
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Listing 2: *A BASIC driver program that calls the program CONVRT and incorporates the machine-language code of CONVRT as a series of DATA statement values.*

```
100 ' MODEL III TL507C A TO D CONVERSION DRIVER
110 DATA 17,0,0,205,43,127,32,10,205,59,127,205,43,127,40,248
120 DATA 24,241,205,59,127,205,43,127,32,248,33,0,0,205,43,127
130 DATA 32,6,205,59,127,35,24,245,195,154,10,19,122,179,32,6
140 DATA 33,255,255,209,24,242,219,255,230,1,201,62,2,211,255
150 DATA 205,74,127,62,1,211,255,205,74,127,201,6,25,16,254,201
160 FOR I=32512 TO 32590
170 READ A: POKE I,A
180 NEXT I
190 DEFUSR0=&H7F00
200 CLS: I=0
210 A=USR0(0)
220 IF A=-1 THEN PRINT @ 512+20,"OUT OF RANGE                    ":GOTO 210
230 I=I+1
240 A=(.75*5)-(A-1)*(2.5/128)
250 PRINT @ 512+20,I,INT(A*100)/100;"                    "
260 GOTO 210
```

analog input, which can be the circuit shown in figure 13 or simply a 1.5 V battery connected between ground and the input lead.

Connect the cassette leads either by clip leads or specially wired cable to the cassette DIN jack at the rear of the Model III.

Protect the hexadecimal 7F00 RAM (random-access read/write memory) area and enter the BASIC program. Double-check the DATA statements for correct values. Execute the BASIC program. You should see a slight pause as the machine-language code is moved from the DATA statements to the hexadecimal 7F00 area. The screen should clear, and you should then see the iteration count followed by the voltage value on the screen.

If you do not see a conversion voltage immediately, recheck the power and wiring connections. If the analog input is not properly connected, you should see the "OUT OF RANGE" message.

The ADC components and timing are not critical, and if you experience trouble, chances are it's in the wiring or machine-language code. You may troubleshoot the circuit by outputting pulses by the following BASIC code:

```
100 OUT 255,1
110 OUT 255,2
120 PRINT @ 512+20,INP(255)
      AND 1
130 GOTO 100
```

This code outputs clock pulses at a very low data rate but one still sufficient to cycle the ADC through the ramp voltages in a few seconds. The input should alternate between 0 and 1, depending upon the analog input voltage.

How Does It Work?

Damn fine! All kidding aside, this is one of those projects that works extremely well, thanks to the specifications of the TL507C chip. The values in table 2 show the output obtained from various analog inputs. Inputs above +3.75 V and below +1.25 V are considered out of range, but all other inputs are measured very accurately.

The number of samples (conversions) per second is about 6. Actually, each sample should take anywhere from about 2 clock pulses (1 millisecond [ms]) to a worst case of about 256 clock pulses (128 ms), corresponding to a range of 1000 to 7.8 samples per second. However, the sluggish BASIC interpreter reduces the number of samples per second to about 6, regardless of the analog input voltage. This conversion rate could



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Digital Voltmeter	Screen Value
<1.26	OUT OF RANGE
1.30	1.30/1
1.40	1.42
1.50	1.50/2
1.60	1.58/9
1.70	1.69/70
1.80	1.79/80
1.90	1.89/91
2.00	1.99/2.01
2.10	2.09/.11
2.20	2.18/9
2.30	2.28/9
2.40	2.40
2.50	2.48/9
2.60	2.59
2.70	2.67/9
2.80	2.79
2.90	2.89/90
3.00	2.98/9
3.10	3.08/9
3.20	3.18
3.30	3.28/9
3.40	3.37/8
3.50	3.47/9
3.60	3.57/9
3.70	3.69
3.74	3.73/5
3.76	3.75
>3.76	OUT OF RANGE

Table 2: *Test results show an excellent linearity for analog input voltages from .25 × V_{cc} through .75 × V_{cc}.*

be "cranked up" by increasing the clock-frequency output on CASSOUT.

The accuracy of the conversion is unaffected by such system functions as real-time-clock interrupts because the program counts directly each clock pulse.

ADC Applications

In my project presented in the January BYTE article, I used transducers to convert light and temperature to voltage levels, which were then read by an ADC and input to the computer as digital information. There are many different types of transducers that convert other physical quantities into voltage levels. This simple and inexpensive ADC can be used to monitor the outputs of such devices and send them to the Model III for recording and processing. In the next two articles of this series, I'll look at simple and inexpensive transducers and show you how to use ADCs for the Model I, Model III, and Color Computer. ■

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The Case of the Purloined Object Code: Can It Be Solved?

Part 1: The Problems

A specialist in software and high-technology law explains why new laws are necessary.

Richard H. Stern
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Three recent decisions of federal tribunals on whether object code in read-only memories (ROMs) is protectable under the U.S. copyright laws show that copyright protection against competitive unloading and duplication of ROMs is insecure. The three decisions suggest that unless and until a more satisfactory software protection law is enacted, software proprietors' exclusive rights to ROMs and other important forms of software will remain doubtful. Devising a proper software law is not a simple matter, however, for conflicting interests pull in different directions and accommodation of these interests is difficult.

This two-part article reviews the problems in using copyright law to protect object code and other software, focusing on the unloaded-ROM problem and using the three ROM cases to illustrate the difficulties faced. The article then comments briefly on the unsatisfactory and inappropriate protection that present patent, contract, and trade-secret laws provide for software, particularly object code. Next month, I will discuss some of the questions that would have to be answered before a well-considered law on protecting ROMs, object code, or other software could be written. The conclusion is that we can solve the case of the purloined object code, but only after answering some difficult questions about software policy.

About the Author

Richard H. Stern is a lawyer specializing in intellectual property and antitrust law. As Chief of the Justice Department's Intellectual Property Section, he tried and supervised the government's patent and antitrust litigation, including the computer software patent cases in the Supreme Court. He is now in private practice in Washington, DC, dealing with the problems of high technology and computer software. Mr. Stern also has a degree in electrical engineering.

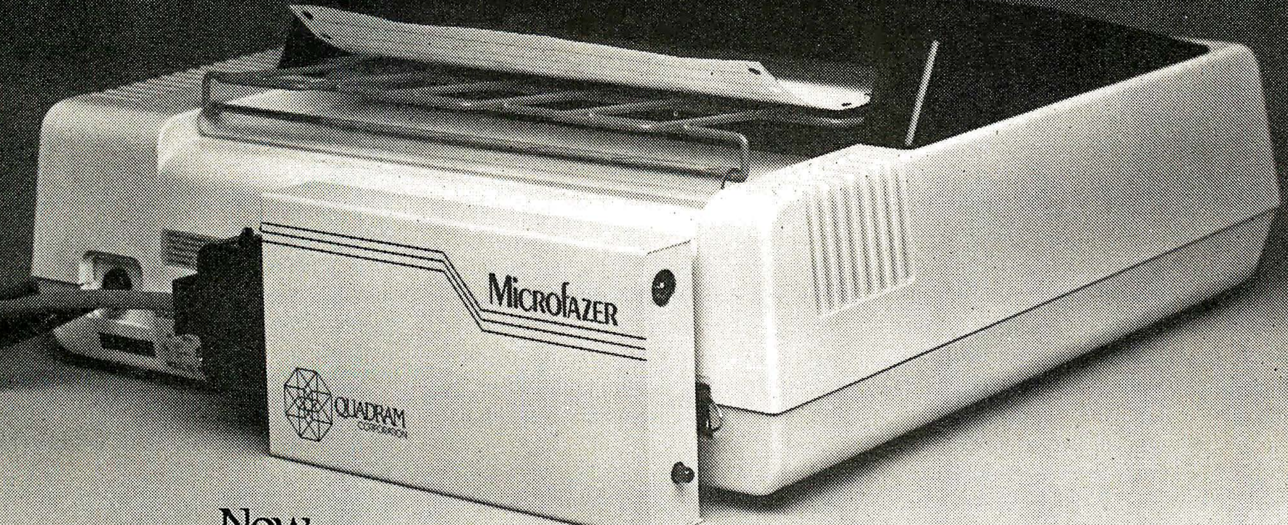
The ROM Cases

The three unloaded-ROM decisions go very different ways, partly because of their facts, but at least as much because of the extraordinary difficulty of the legal issues. In one case, the court held that unloading and duplicating a ROM was not a copyright infringement. In another, the court held the opposite. The third tribunal refused to decide the question because it was too difficult.

The Compuchess Case: The first U.S. decision on whether the federal copyright laws protect object code or ROMs involved the Compuchess hand-held calculator game. When Data Cash marketed Compuchess in 1977, it unwisely believed that it was technologically infeasible to unload a ROM. Accordingly, Data Cash took no special legal or technical steps to protect the object code in the ROMs of its games. This turned out to be a serious mistake. A competitor brought a lower-priced knockoff game on the market, containing a ROM unloaded from the Compuchess ROM. This set the stage for the first lawsuit over purloined object code. (*Data Cash Systems, Inc. v. JS&A Group Inc.*, 480 F. Supp. 1063 [N.D. Ill. 1979], aff'd on other grounds, 628 F. 2d 1038 [7th Cir. 1980].)

The software proprietor lost when the trial court held that object code was not a "copy" of the copyrighted source code, as far as the definition of "copy" under the copyright laws was concerned. A copy of source code would have to be source code, not object code, and definitely not a mechanically utilitarian device such

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The Protection of Video-Game Displays

This article does not attempt to explore in depth a different aspect of copyright law relating to computer programs—the protection of video-game displays, apart from the programs used to generate them. I will briefly touch on the point in this text box, but the issues are too complex (and too peripheral to those discussed in this article) to do them justice. Accordingly, in a subsequent article, I will describe how the courts have recently begun to protect the audiovisual images associated with particular subroutines in computer code used to generate output displays in the video monitors of video-game machines.

A pervasive issue is how close one game's "characters" and "plot" can come to that of another game before there is an infringement, assuming that the second game is not just an unloaded-ROM copy of the first. In one puzzling decision, which probably goes further than any other, the court protected Pac-Man against K. C. Munchkin, an enhanced version of Pac-Man. In another case, however, the court refused to protect Asteroids against the enhanced version Meteors. Other pending cases involve the issue of "speed-up" kits—whether the seller of a video-game machine can stop a customer from putting enhancement ROMs into the machine.

A few tribunals have been persuaded that the video game itself constitutes some kind of audiovisual work of authorship, or that the fixed subroutines within it do. See, e.g., Atari, Inc. v. North Amer. Phillips Consumer Elec. Corp., *672 F.2d 607 (7th Cir. 1982);* Stern Electronics, Inc. v. Kaufman, *523 F. Supp. 635 (E.D.N.Y. 1981), aff'd, 669 F.2d 852 (2d Cir. 1982). The International Trade Commission seems initially to have rejected the argument, but later to have accepted it. In this view, the copyright registration based on filing a video tape of a play mode performance containing audiovisual image subroutines 1 through* n *confers pr tection against performance of any permutation of any number of the* n *audiovisual image subroutines.*

I find this theory difficult to believe, but video-game manufacturers have in some way persuaded several courts to believe it. Accordingly, there must be something to the argument.

It should be noted that the argument, good or bad, would appear inapplicable to data processing and other ordinary computer applications. Video games contain continuous audiovisual real-time output displays made up of permutations of the image subroutine displays, such as the explosion image display sequence of the Galaxian game, with each part or image subroutine (or else their aggregate) claimed to be an audiovisual "work." But the output of a data-processing program would seem to be only a printout of tabulated data or the like. It would seem difficult to find anything in the data-processing output that corresponds to subroutines in the program and that could be characterized as a "work." The only work of authorship in sight, in a data-processing context, is the program itself, not the output. Perhaps some pie-chart graphics or the like could be considered a work of visual or graphic arts.

as a ROM. In so ruling, the court relied on prior cases holding that such physical objects as buildings and dresses were not infringing copies of the blueprints or patterns for those buildings or dresses. In addition, the court expressed its opinion that object code, when physically embodied, is not directly or indirectly protectable under the copyright laws. Therefore, unloading object code from a ROM (or, presumably, from a tape or disk) is not infringement of a copyright on any form of the program.

The second point raises a fundamental problem with use of copyright to protect ROMs, disks, and tapes. The copyright laws were enacted under the Copyright Clause of the U.S. Constitution, which authorizes Congress to pass laws protecting the rights of "authors" to their "writings." A program written in a high-level language is generally recognized as a literary work and the writing of an author. It meets the general test of being a means of communicating ideas or emotions from one person (the author) to another (the reader, viewer, listener, etc.). Perhaps assembly code is in the same category. But a program in object code is generally unintelligible to human beings (the vast majority of whom are unable to read object code). Probably more important, object code is not intended for a reader, viewer, or listener. Rather, it is intended to be a utilitarian object—to operate a processor in response to data inputs with which it coacts to produce outputs. The outputs may be intelligible and communicate ideas or emotions, but the outputs are not the object code—they are something else, a third thing.

The problem with object code, as the court in the Compuchess case saw it, is that it is not a medium of human-to-human communication. As the court said, "The 'source program' is a writing while the 'object program' is a mechanical tool or machine part." The ultimate rationale for the second point made in the Compuchess case is that the copyright laws are intended to protect media of human communication and not functional, utilitarian objects. It is unclear, however, whether the court was talking only about ROMs themselves or also about printouts or "dumps" of ROMs. The logic appears to apply to both.

The Galaxian Case: The second purloined-object-code case involved coin-operated video games. A major U.S. distributor of arcade game machines, Midway, secured exclusive U.S. rights to the Galaxian video game from its Japanese originator. The game machine contains a microprocessor that combines player signal inputs (lever and button signals) with program information from a ROM (or several ROMs) to drive the video display.

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The Structure of the Galaxian Game Machine

The Galaxian video-game machine has two printed-circuit boards, a motherboard, and a piggyback memory board. The motherboard has a Z80 microprocessor, two 24-pin sockets for the piggyback memory board, and two character ROMs. The character ROMs contain the code for the various images displayed on the screen.

The piggyback memory board has five program ROMs and two sets of 24 pins that fit into the sockets on the motherboard. The program ROMs contain code for the sequence of positions assumed by the images derived from the character ROMs and code for the responses to and interactions with the signals derived from player inputs.

The microprocessor produces signals for the output video display that are derived from (1) the signals coming from player inputs and (2) the code in the ROMs.

When Midway introduced the game machine into the U.S. market and it became a commercial success, importers began to sell competing versions of the game machine with duplicated ROMs. Midway sought to stop this by complaining to the U.S. International Trade Commission (ITC), a federal agency charged with preventing unfair acts and practices and unfair competition in U.S. import trade. The ITC does so by issuing orders prohibiting the importation of products that infringe U.S. patents, trademarks, copyrights, and the like.

The software proprietor sought copyright protection on two aspects of the Galaxian game's display. Midway filed two video tapes with the U.S. Copyright Office, which issued copyright registration certificates to Midway on them as "audiovisual works." The two tapes showed, respectively, output displays of the Galaxian game machine during (1) the "attract mode" and (2) the "play mode." (Midway did not attempt to register the source program or the object code.)

The "attract mode" of a coin-operated video-game machine is designed to attract customers. It is a short, repeating sequence of a simulated game, similar in effect to a film loop. It fixes as stored data the interaction, on one short occasion, of a skilled player and the code in the ROM. For copyright purposes, what is important is that the attract mode is not input-dependent, but fixed and unvarying in terms of its total content and the sequence in which images appear.

The "play mode" of a video-game machine is the actual game-play sequence, which supersedes the attract mode in a game machine whenever a quarter is inserted into the machine. The play mode display is never quite the same twice, after the first several seconds, for no two player-input signal sets are ever identical. Within any total play mode sequence, however, are certain recurrent subroutines. Any time that an alien insect image contacts the image of the player's Earth-defender rocket ship anywhere on the video screen, an explosion image sequence occurs. This is a set audiovisual display of the mutual destruction of the two images. A similar subroutine is carried out when a player's missile image contacts (hits) an insect image. Moreover, if the game has a background landscape or a maze on which the action is superimposed, that may be a fixed sequence. Games with "characters," such as a protagonist, may have them as fixed sections of code stored in one place.

By way of analogy, to compare the two modes for copyright law purposes, consider an ordinary video tape of *Casablanca*. No matter how many times anyone plays the tape, Rick never gets on the plane to Lisbon, he always shoots Major Strasser, Louis always calls for a roundup of the usual suspects, and Rick and Louis always go off to join the Free French Forces. That is how the attract mode operates. Now, im-

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agine an "interactive" *Casablanca*, an art form of the future, dependent on viewer input. Sometimes Rick gets on the Lisbon plane with Ilsa, sometimes Strasser shoots him first, sometimes Louis arrests Rick, perhaps sometimes Strasser gets Ilsa, and so on. But some recurrent subroutines are also in this *Casablanca;* wherever Rick says, "Play it again, Sam," Sam will always oblige by playing "As Time Goes By" on his piano, and after any shooting, Louis will always say, "Round up the usual suspects." That is how the play mode of a video game may operate.

Midway claimed copyright protection against the importers under both copyright registrations. The ITC agreed that the copyright on the Galaxian attract mode "audiovisual work" had been infringed because the importers simply unloaded and reloaded the whole ROM without bothering to identify and vary the fixed data stored in the attract mode portion of the ROM. This caused the importers' machines to duplicate or perform the very same attract mode performed by Midway's machines, which was infringement of Midway's copyright on the attract mode. But the ITC refused to rule on whether Midway could also gain protection on the basis of the importers' unloading and reloading the play mode's program data (object code) from the ROM. (*Certain Coin-Operated Audio-Visual Games and Components Thereof*, ITC Docket No. 337-TA-87, Opinion of June 26, 1981.)

First, the ITC said that registering a video tape of a single play mode performance of the Galaxian game is not a registration of every other possible Galaxian game performance. Since there are millions of possible Galaxian play mode performances, allowing registration of one performance to confer protection for the entire set of possible performances would be the equivalent of copyrighting the idea of the Galaxian game itself. But the copyright laws do not allow games or other ideas to be protected as such. In short, although the ITC did not put it in these terms, registering one computer run of a program or one output display does not constitute registering a claim of copyright on all runs, all displays, or the algorithm (or program) for all runs.

Second, the ITC said that the human player is perhaps a coauthor of the Galaxian play mode performance or output. The ITC asked: Can a work coauthored by a person and a computer (the Galaxian game machine with its processor, ROM, etc.) be protected by the computer owner's copyright? The ITC refused to answer this difficult question because it believed that the narrow basis on which it had decided to dispose of the case permitted it to avoid the issue.

It is unfair to duplicate object code because doing so violates the spirit of the copyright laws even though not their letter.

The ITC found a way to decide the case that made it possible not to rule on such difficult legal questions as whether the program for the Galaxian play mode or ROM had been, or could in any way be, copyrighted or infringed. The importers had all copied the attract mode, which was protected as a copyrighted audiovisual work. Their machines could therefore be excluded from the U.S. on that ground alone. The other more difficult questions could, if necessary, be decided in subsequent cases involving other video games. (One such case is now pending before the ITC.)

Finally, the ITC noted that its disposition of the Galaxian case made it unnecessary to reach an issue urged upon it by the present writer. This was whether it was unfair to unload and reload program data (object code) from a ROM even though it was not copyright infringement to do so. In the view that the writer urged, it is unfair to duplicate object code (as the ITC statute uses the term "unfair") because doing so violates the spirit of the copyright laws even though not their letter. Understandably, the ITC may have felt reluctant to fill in a gap in the copyright laws when Congress had failed to do so. Despite its avoidance of many important issues, the ITC's opinion in the Galaxian case is perhaps the most perceptive and instructive one in the whole object code/unloaded-ROM field.

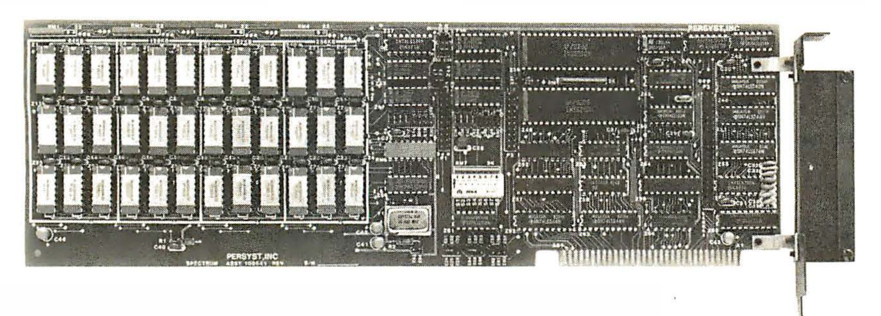
The TRS-80 Case: The latest lawsuit over object code involves the input/output (I/O) interpreter program for the TRS-80 microcomputer. (*Tandy Corp. v. Personal Micro Computers, Inc.*, 524 F. Supp. 171 [N.D. Calif. 1981].) Tandy's TRS-80 microcomputer includes an I/O program stored in a ROM. The TRS-80 I/O program interprets BASIC source code into machine-intelligible object code. This interpretation process is essential to the use of the computer, the trial court noted, because human beings using the TRS-80 cannot understand and communicate object code, while machines cannot understand (by that term, the court meant cannot be directly operated by means of) a human-intelligible, high-level language such as BASIC source code. Of course, the same principle applies to the I/O program itself. It, too, must be transformed into object code before the computer can understand and use it. Tandy therefore compiled the I/O program and loaded it into a ROM, which was placed in its TRS-80s. This was a ROM whose silicon chip's physical pattern corresponded to the object-code form of the I/O program. (Presumably, this was a custom ROM, not a PROM, but that does not seem material to copyrightability.)

Tandy had apparently registered the program for copyright as a source program. Tandy sued the defendant, also a manufacturer of microcomputers, when it discovered that the defendant had unloaded the ROM and was using the program in its microcomputers. Tandy's I/O program was presumably copyrightable when it was written out in BASIC source code or another human-

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Object Code, Piano Rolls, and Sanskrit

Some programmers claim to be able to read object-code printouts. It is unclear, under copyright law, how many people must be able to read a message for it to be deemed a copyrightable "writing" or a "copy." In one case, now of questionable authority, the U.S. Supreme Court held that perforated player-piano rolls were not "copies." Thus, they were not infringements of copyrighted sheet music, even though some persons skilled in making piano rolls claimed to be able to read them as others read ordinary musical staff notation. The Court pointed out that, in any event, a piano roll is not intended to be read like sheet music. Moreover, it noted, extending similar protection to piano rolls as "copies" would require extending similar protection to music-box cylinders and other mechanical objects, an extension of copyright law that the Court considered improper.

On the other hand, it is generally believed that a book written in Sanskrit or a listing of a source program in FORTRAN or APL may be copyrighted, even though relatively few persons can read them. Copyright protection has even been granted to a book of meaningless five-letter "words" intended for use as cable code, where the users were supposed to supply their own arbitrary meanings for the "words."

Opinions probably differ widely among lawyers as to whether intelligibility of the message to a large number of persons is a requisite of copyright.

intelligible language. But the defendant had duplicated the ROM, not the source code. This raised the question, as in the Compuchess case, whether Tandy's or the defendant's ROM chip was a "copy" (as the copyright statute uses that term) of the copyrighted TRS-80 I/O program. The defendant moved for a pretrial summary judgment in its favor on the ground that regardless of whether its ROM duplicated Tandy's ROM it was not a "copy" of Tandy's copyrighted I/O program.

The court rejected the motion, refused to dismiss Tandy's complaint, and said that the case must go to trial. Its reasoning was as follows:

- The statute says that works can be "fixed" by embodying them in any "tangible medium of expression, now known or later developed, from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine."
- A silicon chip is a "tangible medium of expression" within the meaning of the copyright statute.
- "The imprinting of a computer program on a silicon chip, which then allows the computer to read the program and act upon its instructions, falls easily within this definition" of "fixed."
- Therefore, the copyright laws protect a program fixed in the form of a ROM chip. Unloading and reloading a ROM is copyright infringement of the copyright on the source program.

The court recognized that in the Compuchess case the trial court had held the opposite. But it simply disagreed with that court's reasoning and refused to follow it.

The court's conclusions in the TRS-80 case about copying ROMs do not seem to follow properly. There appear to be some gaps in the court's logic, which it has filled with unstated and perhaps incorrect assumptions. The court's remarks about the program being "fixed" in the ROM chip ignore (1) the statute's requirement that a "copy" of the program be made before an infringement can be found, and (2) the problems stemming from the fact that the statutory definition of "fixed" parallels the statutory definition of "copies," so that the various legal problems do not go away by focusing only on "fixed."

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Worst of all, the court seems to have badly confused itself with its metaphors. The court speaks of a computer's "reading" or "understanding" object code, and "act[ing] upon its instructions," analogously to a person's reading or understanding a source program or other literary work. But the court mistakes its figure of speech for reality. Computers and other machines do not *read* books or *understand* them in the same sense as a person does. Yet, the court's reasoning assumes this. Thus, "perception" by a machine or "communication" to a machine is assumed to be covered by the statute. But that needs to be decided, not assumed. The terms "perceived" and "communicated" in the statutory definitions of "copies" and "fixed" may well contemplate nothing of the kind. Probably, the opposite assumption would be sounder.

This flushes out the basic issues in the unloaded-ROM cases:

- whether under the present statute, "human intelligibility" is a requirement for copyright
- whether copyright can be used to protect objects intended to perform a utilitarian function rather than to act as a medium for communicating ideas

Those are the real points of difference, whether well articulated or not, between the two courts in the Compuchess and TRS-80 cases, and they underlie the issues that the ITC considered too troublesome to decide in the Galaxian case.

Protecting Software Under Present Law

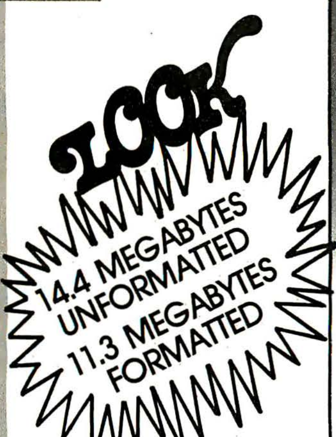
If one had to choose only among expanding the laws governing copyrights, patents, trade secrets, or contracts, copyright would probably be the best of a bad lot. But it is a poor second to a specific software law based on the broader power of Congress to regulate commerce than to regulate "writings." Perhaps the best way to understand this is to briefly survey the concepts and structures of those respective bodies of law, focusing first on how they apply to software and then on specific software problems that are not dealt with satisfactorily. The purpose of the following overview is to show how the structure and concepts of copyright, patent, trade secret, and contract law relate to the things they were evolved to deal with, and how they much less satisfactorily relate to software.

What Does the Copyright Act Do for Software?

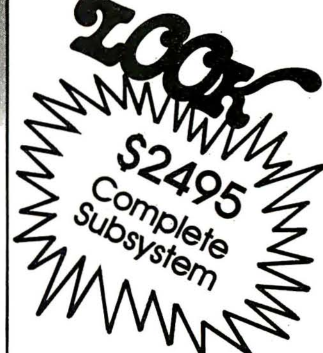
The three unloaded-ROM cases indicate that the copyright laws furnish object code with little protection, debatable protection, or no protection at all. The present copyright statute, despite two amendments, has probably bungled the protection of object code. Despite optimistic claims that "the copyright problem was resolved by the Computer Software Copyright Act of 1980" and "object code is now clearly subject to copyright laws" (see BYTE, May 1981, pages 130, 138), the reality is that "subsequent revision (most particularly the Computer Software Copyright Act of 1980) continues to provide inadequate protection" (BYTE, May 1981, page 138).

Copies: True, the 1980 Act contains a definition of "computer program" that at least arguably includes object code (see BYTE, May 1981, page 130). But the Act stops there and does not go on to say that unloading a program from a ROM or otherwise electronically duplicating a program (specifically, object code) constitutes unlawful copyright infringement or the making of a forbidden "copy." That further step is essential to our having secure copyright protection for object code if the following analysis is correct.

The copyright statute is a maze—or certainly a very complex network. The copyright statute has a key node through which every important signal must pass. This is the definition of "copy." Only a "copy" of a work can be protected; only a "copy" of a work is an infringement. The statute defines a "copy" of a program or other work as a stable, tangible embodiment of the work from which the work "can be perceived . . . or otherwise communicated." The quoted words may well compel the conclu-







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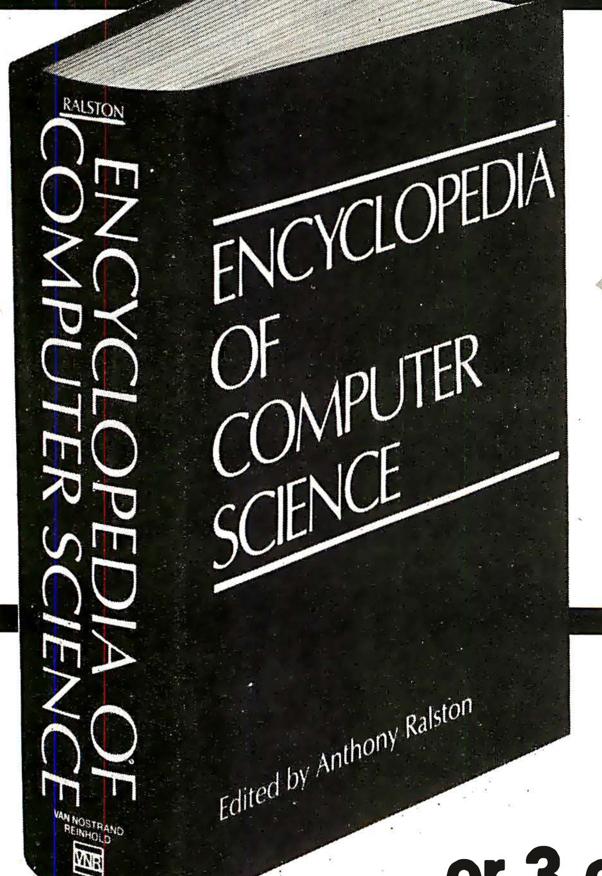
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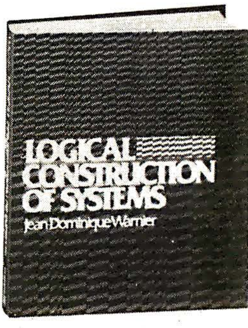
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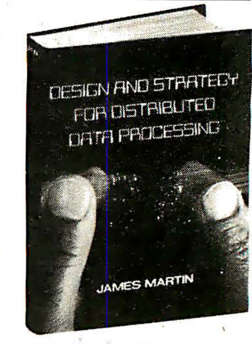
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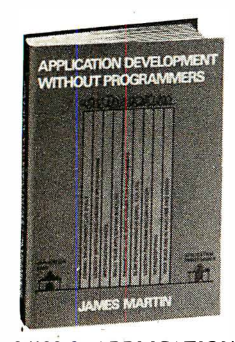
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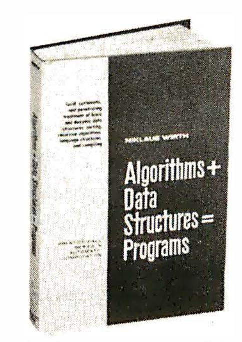
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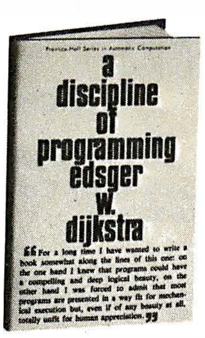
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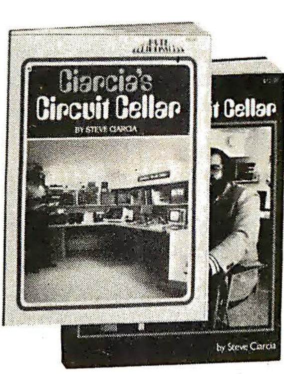
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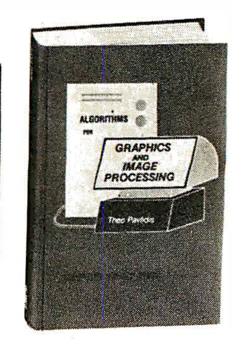
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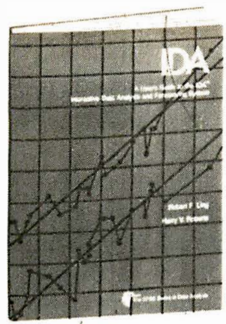
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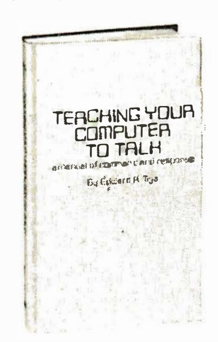
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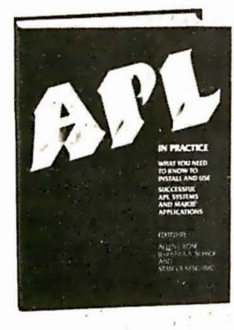
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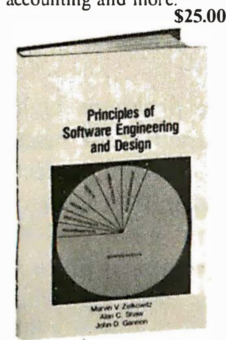
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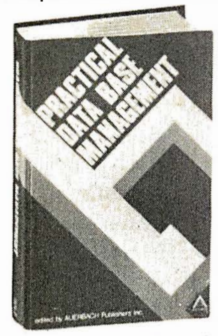
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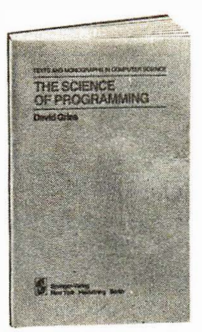
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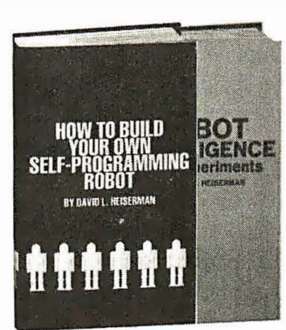
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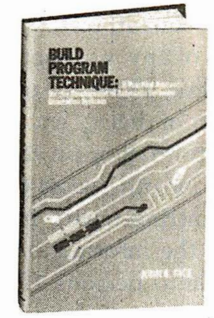
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Disassembling Object Code and Copyrighting Chairs

An argument for intelligibility of object code could be made on the basis of reverse-compiling. In principle, object code can be disassembled and converted into an intelligible form if proper parameters are known. For example, programs are available to convert (disassemble) object-code versions of programs for various microprocessors into assembly code. The assembly code is widely human-intelligible, at least in the software trade. It can be used to develop, and perhaps even computer-generate, high-level source code, which is generally recognized as both human-intelligible and copyrightable. Obviously, the same thing could be done for ROMs, although it is not clear that the end product of this process will always be the very same source program as that initially compiled to generate the object code.

The argument based on reverse-compiling is that although object code may not be directly intelligible to most people, with the aid of a computer and program it can be put into an intelligible form. It is unclear, however, whether the fact that unintelligible symbol set A *can be converted into intelligible symbol set* B, *by a transformation process, is the full equivalent of the copyright law's statutory concept that set* A *is a material object from which the underlying work (which may be equated here to intelligible symbol set* B) *can be "perceived or otherwise communicated." It is one thing to perceive a video tape of* Casablanca *with the aid of a TV set. It may be quite another thing to perceive a transformation of object code with the aid of a computer.*

For one thing, the video tape of Casablanca *is intended to be used primarily as an object of communication, while the ROM is intended to be used primarily as an object to operate a machine. This point was noted in several early piano-roll copyright decisions. Second, the transformation argument seems to prove too much and thus leads to unacceptable results. Buildings and chairs are clearly not writings. Thus, they are not copyrightable. Yet, either can be subjected to an optical-scanning process and, with the aid of a computer, be made to generate a set of intelligible and copyrightable blueprints. If a ROM is copyrightable simply because it can be made to generate source code or its equivalent, so too is a building or chair. The latter is clearly not the law, which suggests that something must be wrong with the argument. The argument based on the possibility of reverse-compilation is thus probably unsound.*

sion that the potential of sapient perception and communication is essential to copyright protection. That is, the alleged copy of a program or other work must be intelligible to human perceivers and communicatees. It is not enough that it be machine-readable, for machines do not *perceive* works and one cannot *communicate* works to them except in a metaphorical sense. That is not the commonsense usage of "perceive" and "communicate." The alleged copy (object code), to be a "copy," thus would have to communicate something to humans in terms of idea or emotion, and they would have to be able to perceive it. Yet, even in its most communicable form (hard copy rather than ROM or disk), object code is a string of 0s and 1s unintelligible to most, even if not all, potential readers. In its ordinary physical form, such as a ROM, it is even less of a means of communication. (See the text box Disassembling Object Code and Copyrighting Chairs.)

Further Amendments: To be sure, we could try still another amendment of the copyright law to overcome the problem. We could say, *in so many words*, that unauthorized electronic duplication of any information stored in a tape, disk, ROM, or other product capable of being encoded with program information (in the form of object code or otherwise) constitutes copyright infringement, irrespective of whether the information encoded is intelligible to persons. That is the cheap and dirty solution, usually favored heretofore, but it is unwise for several reasons.

First, if the trial court in the Compuchess case was right, there remains a constitutional problem. Object code may be protectable under a statute regulating interstate and foreign commerce, but not under one regulating "writings." The concept of "writings" in the Constitution may require substantial human-intelligibility of the alleged writing. It also may require that the alleged writing be intended as a medium of communication, rather than intended primarily to serve as a utilitarian object.

Second, copyright law is unsuitable and inappropriate for software. It is a worse vehicle for protecting software than COBOL is for doing advanced mathematical calculations. Copyright law is the result of the evolution of a system to prevent book printers from copying books that were first published by other book printers. When copyright remedies and procedures are applied to other kinds of things, mass-produced products that any claimant wants to protect, those remedies and procedures do an inept job. Copyright now does an awkward and clumsy job of protecting lamp bases, junk jewelry, fabric designs, belt buckles, and toys. It will do no better for code in ROMs, disks, and tapes.

Even without the problems highlighted by the unloaded-ROM cases, copyright law is ill-suited to protecting software. The May 1981 issue of BYTE contains several surveys of the copyright law and other laws protecting software. They describe what follows in more detail and from a different perspective.

Subject Matter of Copyright: Copyright protects particular "expressions" (specific formulations or embodiments) of ideas, suiting copy-

right more or less to protection of source code and documentation from outright duplication. But copyright law does not protect ideas, formulas, processes, and the like, as such. Accordingly, it cannot protect algorithms or the concepts on which programs are based.

Infringement and Remedies: Making and selling a "copy" of a copyrighted work is "copyright infringement," for which the standard remedies are:

- destruction of all offending copies
- award of damages to the copyright owner for the profits that would have been made on sales of copies diverted from the owner
- award of the infringer's profits on sales (if this is a separate, nonoverlapping item)
- an injunction against further copying

The copyright laws do *not* deal, however, with *use* of copyrighted material. Moreover, the copyright laws do not contemplate intermediate remedies, such as mandatory reasonable-royalty licensing. Finally, they have no express or formal means for dealing with the severe problems of innocent purchasers who wish to resell the product.

Mere ownership and personal use of an infringing copy of a copyrighted work is not itself an infringement, but its resale is. Thus, even if copyright law protected ROMs, it would not prevent a customer from using an unlawfully copied ROM that had been purchased, or require the payment of damages for using the ROM. But it would prevent resale of the ROM or a microcomputer in which the ROM was an essential part. It is unclear whether the owner of the copyright on a ROM could get a court order for the destruction of the ROM when it is in the hands of a purchaser.

Plagiarism: The concept of nonduplicative copying or "plagiarism" is recognized in copyright cases involving books, plays, and music. But the concept in the software field is virtually undefined and prior copyright precedents are of almost no value. It is therefore unpredictable when a court will call one program a copy of another when the two are not identical. The inevitable importation of concepts developed for books and plays must add a very substantial random element to the decision process.

Patent Law

Patent law is in many ways theoretically or conceptually more suited than copyright to software. But it too has severe problems. First, it is clear that algorithms and concepts of programs, as well as pure programs considered in isolation, are unpatentable under the present patent law. Programs in the matrix or setting of a machine system, however, may be patentable. For example, a machine system for molding and curing rubber is patentable even though the central elements of the system are a ROM-stored program and microprocessor designed to cooperate with other elements to cause the mold to open after an optimum heat history. Data-processing applications may run into more problems.

A patent is granted only for new and unobvious subject matter. Improvements in programs seldom meet this difficult test. Moreover, 70 percent of all issued patents that reach appellate courts are held invalid. A new kind of ROM as such could be patented as a new machine, but an old ROM with a new program encoded in it could not. It would be considered like trying to patent an old player piano with a new piano roll in it.

The remedies of the patent system are generally similar to those of copyright, although more suited conceptually to software. Thus, *using* a patented product or process without authorization is patent infringement, unlike unauthorized use of a copyrighted work. Moreover, the concept of patent infringement is much more definite than copyright infringement because a patent has "claims" specifi-

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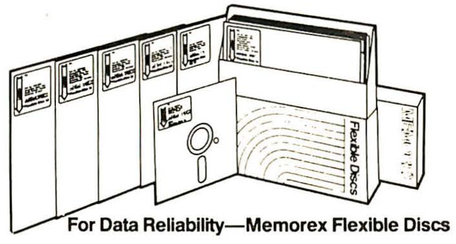
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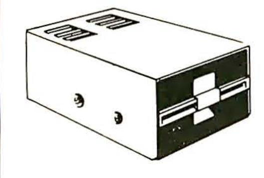
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cally defining its coverage. For example, if someone could legitimately claim inventorship of the idea of subroutines and if the patent laws would somehow (under an amended law) reach such things, it would in principle be possible to write a patent and patent claim covering GOSUB. Of course, that is not how the copyright laws operate, and one could not, even in principle, copyright GOSUB.

Trade Secret and Contract Law

Trade secrets, and contractual arrangements tied in with reliance on trade secrets, are the most widely used form of software protection in the United States at this time. (In large part that reflects the inadequacy of present copyright law and patent law.) Since this body of law is nonfederal, unlike patents and copyrights, it varies widely from state to state. Ideas can be protected under contract law. Therefore, difficulty with algorithms and program concepts does not apply here. By the same token, parties can contractually bind *themselves* (but not others) not to unload ROMs or other forms of object code. The only limits to contracts are set by public policy and by the limitations of drafting ability.

The real problem, however, is with third parties. A contract or duty of secrecy between Tom and Dick does not bind Harry. Unless Harry knowingly induces Dick to breach a secrecy agreement with Tom, Tom probably has no remedy against Harry. Thus, Harry may buy or borrow Dick's machine with Tom's ROM, or lease it from Dick, or foreclose on it, and then unload the ROM with impunity. Even if Dick lends, leases, or sells to Harry in violation of Dick's contract with Tom not to do so, Tom has no right against the unknowing (and therefore innocent) Harry. There may be ways to minimize these risks, by restrictive agreements or leases, but they are impractical and/or impossible with such mass-marketed products as those involved in the three ROM cases discussed above.

The secrecy of a trade secret is fragile. Contract rights are ineffective against third parties. Restrictive agreements may also fail if the trade secret becomes public. In combination, trade secrets and contracts probably protect software proprietors better than present copyright law does, but they probably give less protection than an amended copyright or patent law could furnish. None of these different systems, however, is capable of protecting software effectively because of their main commitments in other directions.

The problem with using these several forms of law to protect software is that it takes too much creativity and energy to persuade the courts to apply them sensibly to software. These other kinds of law have evolved acceptable solutions for the problems with which they ordinarily deal. It makes good sense not to protect mere ideas under copyright and patent law. It makes good sense to protect plans and blueprints, but not buildings or machines, under copyright law. It makes good sense not to bind third parties to the contracts of others. It makes good sense to protect trade secrets only when they are not widely known. But none of this deals properly with the interests at stake in software and the kind of fact patterns characteristic of software ownership and use controversies.

Dealing with the Special Problems of Software

A proper system for protecting software from misappropriation would have to:

- accommodate the conflicting interests of the various groups concerned with the use and protection of software
- devise remedies tailored to deal with the different ways in which software can be appropriated
- be structured for ease of access to the system and ease of administration
- generally encourage development of new software without discouraging the use of software or the growth of the industry

The second part of this article, which will appear in next month's issue, will address those issues. ■

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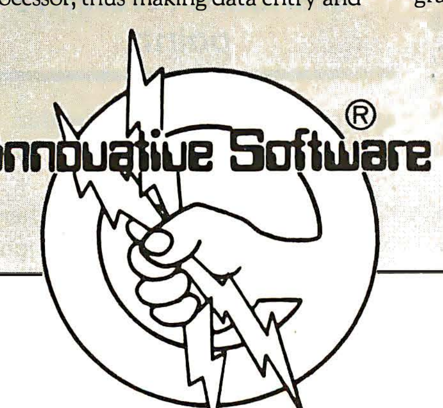
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A Comparison of Five Compilers for Apple BASIC

Speed isn't the only criterion to consider when choosing a compiler.

Joseph H. Taylor and Jeffrey S. Taylor
272 Hartley Ave.
Princeton, NJ 08540

The BASIC language, in the form commonly available on personal computers, has been a great boon to the spreading popularity of these machines. BASIC is easy to learn, usable in a wide range of applications, efficient in memory usage, and inexpensive to incorporate into hardware. The enormous success of computers such as the Apple II, the Commodore PET, and the Radio Shack TRS-80 is, we think, largely a result of their friendly implementation of BASIC—a high-level language stored in ROM (read-only memory).

However, the BASICs used in nearly all personal computers suffer from one serious drawback: they are slow. This is largely a result of BASIC being present in the form of an interpreter, a machine-language program that supervises the execution of the user's BASIC program. The supervision is accomplished by sequentially scanning the text lines that make up the program at the time the BASIC program is running (that is, at execution time). Each line is decoded to determine the numerical or logical operations desired, and the interpreter calls appropriate subroutines (within its own program code) to carry out the indicated operations.

Our primary yardstick for comparing the five compilers was execution speed, and we used the speed of the Applesoft Interpreter as the standard reference point.

A much more efficient scheme, used in nearly all serious computer applications, is to use a compiler to translate the program's logical structure into code directly executable by the computer hardware. This object code (rather than the source code lines written by the programmer) is stored in the computer's memory at execution time. The program can run much faster than it could under the control of an interpreter because the scanning and decoding is done only once, at compilation time.

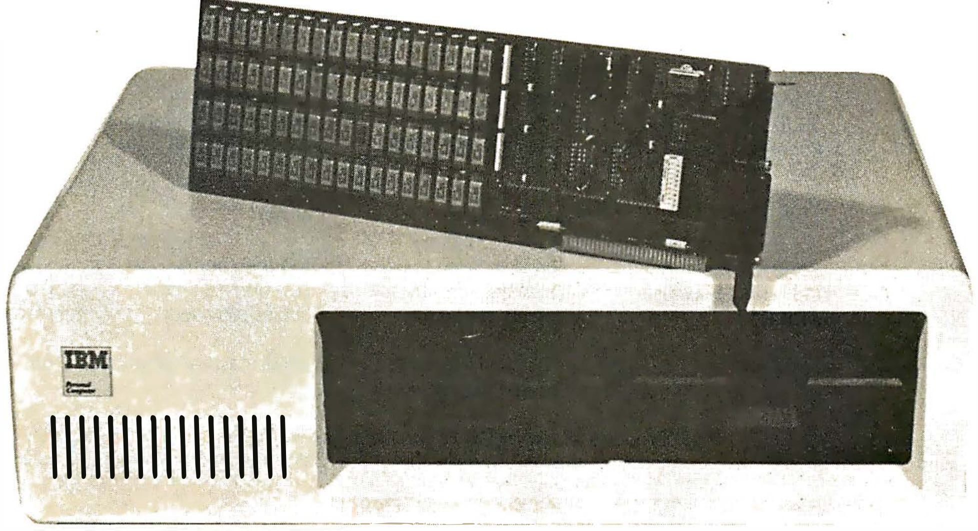
In this article, we review five different compilers designed for use on the Apple II computer, all of which were first marketed during the past year. One of them, the Integer BASIC Compiler by Galfo Systems, works only with programs written in Apple Integer BASIC. Although this language subset is not suitable for some applications—especially those involving extensive calculations or "number crunching"—it is eminently useful in others and produces extremely fast and compact code when used with the Galfo compiler. In some time-critical applications, this speed advantage (typically 10 times faster than interpreted Integer BASIC and 15 or more times faster than Applesoft) might be very important.

The other four compilers reviewed are Applesoft Compiler (Hayden Book Company), TASC (which stands for The Applesoft Compiler,

About the Authors
Joseph H. Taylor is a professor of physics at Princeton University and uses computers (from microcomputers to mainframes) in his research work on pulsars and other phenomena in astrophysics. His son Jeffrey is a student at Princeton High School and carried out most of the tests of the compilers described in this article.

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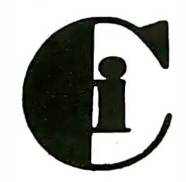
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At a Glance

Name				
Integer BASIC Compiler	Applesoft Compiler	TASC	Expediter II	Speed Star
Type				
Compiles Integer BASIC	These products compile programs written in Applesoft BASIC.			
Manufacturer				
Galfo Systems 6252 Camino Verde San Jose, CA 95119	Hayden Book Co. 50 Essex St. Rochelle Park, NJ 07662	Microsoft 400 108th Ave. NE Belleview, WA 98004	On-Line Systems 36575 Mudge Ranch Rd. Coarsegold, CA 93614	Southwestern Data Systems 10761, Suite E, Woodside Ave. Santee, CA 92071
Price				
$150	$175	$160	$100	$135
Format				
Two 5¼-inch floppy disks (16 sector)	5¼-inch floppy disk (13- and 16-sector available)	5¼-inch floppy disk (13-sector, can be copied to 16-sector)	5¼-inch floppy disk (13- and 16-sector copies provided)	5¼-inch floppy disk (16-sector); hardware key plugs into paddle port
Language				
6502 machine language	6502 machine language	Compiled Applesoft (source not provided)	6502 machine language	6502 machine language
Computer				
Apple II or II Plus, with 32K or 48K bytes of memory and one disk drive. Integer BASIC required in ROM or in the Language Card at compile time.	These products all require an Apple II or II Plus with 48K bytes of memory, Applesoft in ROM or in the Language Card, and one disk drive.			
Documentation				
30 pages; soft binder	27 pages; three-ring binder	97 pages; two-ring padded binder	16 pages; paper cover	54 pages; three-ring padded binder
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Audience				
Anyone writing programs in BASIC for the Apple II computer and needing improved execution speed or security of source code				

from Microsoft), Expediter II (On-Line Systems), and Speed Star (Southwestern Data Systems). All of them compile programs written in Applesoft, a widely used BASIC dialect with good string-handling and graphics capabilities and full floating-point support. The object code produced by these compilers generally runs 2 to 10 times faster than the respective programs being executed under the Applesoft interpreter.

The Compilers and the Tests

Each of the compiler systems is furnished in machine-language form on one or two 5¼-inch floppy disks. The Applesoft compilers are usable on any Apple II or II Plus computer with 48K bytes of RAM (random-access read/ write memory) and one or more disk drives; the Applesoft interpreter must also be present, either in ROM, the Language Card, or another 16K-byte RAM card. The Integer BASIC Compiler requires 32K bytes of RAM and at least one disk drive, and the Integer BASIC interpreter must be present in ROM or in the Language Card at compilation time. The interpreter is not required at execution time, so compiled programs can be run on machines without Integer BASIC.

Our primary yardstick for comparing the five compilers was execution speed, and we used the speed of the Applesoft interpreter as the standard reference point. We wrote (or adapted from the literature) eight benchmark programs, chosen to evaluate different features of the BASIC language. Brief descriptions of each of the eight test programs are given in table 1, and full listings are presented in listings 1 through 8. Some trivial changes in syntax were required, of course, in copying the programs from Applesoft into Integer BASIC, but otherwise the identical programs were run under each interpreter and compiler. The first five programs test integer arithmetic, loops, magnitude comparisons, and array shuffling. The last three programs assess features not implemented in Integer BASIC: The ALPHA program tests string-array handling and string comparisons, and MATINV and FFT test multidimensional array manipulation and some relatively complicated floating-point "number crunching." Our experience shows that the exact choice of benchmark programs is not very important. The better compilers were superior (or at least comparable to the others) for all of the programs tested.

Other criteria besides execution speed are of interest to some users because of particular needs. One of the most important of these is the size of the resulting object-code program. In most cases, the compiled code is larger than the BASIC source pro-



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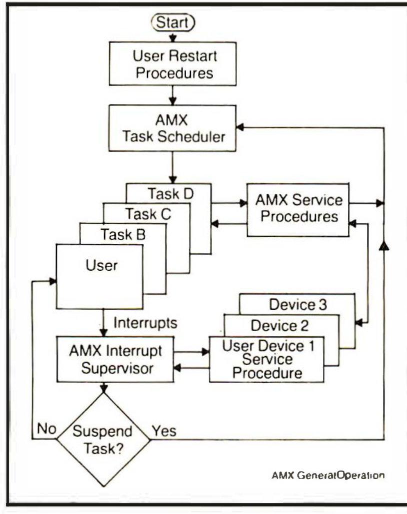
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Program Name	Applesoft Interpreter Execution Time (seconds)	Brief Description of Program
PRIME1	16.9	Generates all prime numbers less than 1000, using the "Sieve of Eratosthenes" algorithm (see "A High-Level Language Benchmark" by Jim Gilbreath, September 1981 BYTE, page 180).
PRIME2	28.2	Generates all prime numbers less than 1000, using the algorithm given by Charles Porter (see "Some More on Performance Evaluation" by Carl Helmers, July 1980 BYTE, page 216).
SIGAV	44.2	Signal-averager program, as might be used in a laboratory data-acquisition system. Uses integer arithmetic.
KBAUD7	46.3	BASIC benchmark used by Rugg and Feldman (Kilobaud, October 1977, page 20).
SORT	24.8	Sorts a list of numbers into ascending order.
ALPHA	15.4	Sorts a list of words into alphabetical order.
MATINV	40.2	Inverts a 10 by 10 matrix.
FFT	22.6	Computes the discrete Fourier transform of a 64-point complex array.

Table 1: *Programs used in execution time comparisons. The times given are derived using interpreted BASIC.*

Listing 1: *PRIME1 program computes all prime numbers from 1 to 1000.*

```
100  REM  **********
110  REM  * PRIME1 *
120  REM  **********
130  HOME :MAX = 1000
140 SIZE =  INT ((MAX - 1) / 2)
150 B$ =  CHR$ (7)
160  DIM FL%(500)
170  INPUT "READY ? ";A$
180  PRINT "START" + B$
190 COUNT = 0
200  FOR I = 0 TO SIZE
210 FL%(I) = 1
220  NEXT I
230  FOR I = 0 TO SIZE
240  IF FL%(I) = 0 THEN 330
250 PRIME = I + I + 3
260 K = I + PRIME
270  IF K > SIZE THEN 310
280 FL%(K) = 0
290 K = K + PRIME
300  GOTO 270
310 COUNT = COUNT + 1
320  REM  "PRINT PRIME" HERE IF DESIRED
330  NEXT I
340  PRINT B$ + "STOP"
350  PRINT COUNT;" PRIMES"
360  END
```

gram and, therefore, requires more disk space and memory. In addition, each compiler system requires a run-time library of support routines to be present in RAM at execution time. The run-time libraries range from approximately 2K to 4K bytes in size. For very long programs these code expansion considerations may be of paramount importance.

Each of the compilers provides a number of options from which the user can choose through a question-and-answer dialogue or "active remark" (REM) statements included in the source code itself. (These active REM statements will be ignored, of course, by the BASIC interpreter; they are used to provide information to the compiler only.) Most of the options serve to control the addresses of the object code and run-time library at execution time—for example, to avoid interference with Apple's high-resolution graphics pages or to allow several compiled programs to share some common variables and a single copy of the run-time library. As another option, TASC permits an active REM to declare any or all of the program's numeric variables to be integers, without having to append the otherwise obligatory percent signs (%) throughout the source program. Because TASC (like the Hayden Applesoft Compiler, but unlike Expediter II, Speed Star, and the BASIC interpreter) evaluates integer expressions using efficient 16-bit integer arithmetic, an integer declaration for all quantities used as integers can speed up program execution considerably.

Ranking by Execution Speed

The results of our execution speed comparisons are presented in figure 1. In all cases, the relative speed for a given compiler was obtained by dividing the Applesoft Interpreter execution time (given in table 1) by the time required to run the same program after compilation. As figure 1 indicates, Galfo Systems' Integer BASIC Compiler was the clear winner for the five programs that it was able to compile. Its generated code ran 1.5 to 8 times faster than that of any of the other compilers, 8 to 12

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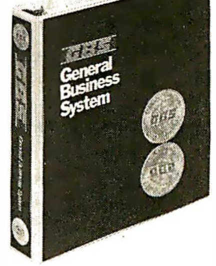
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Listing 2: *PRIME2 also computes all prime numbers from 1 to 1000.*

```
100  REM  **********
110  REM  * PRIME2 *
120  REM  **********
130  HOME :L = 1000
140 B$ =  CHR$ (7)
150  INPUT "READY ? ";A$
160  PRINT "START" + B$
170  DIM A%(1001)
180  FOR I = 2 TO L
185 A%(I) = 1
190  NEXT I
200 X = 2
210  IF 2 * X > L GOTO 230
220  FOR I = 2 * X TO L STEP X
222 A%(I) = 0
224  NEXT I
230 X = X + 1
240  IF X = L THEN 270
250  IF A%(X) = 0 THEN 230
260  GOTO 210
270  PRINT B$ + "STOP"
280  FOR I = 2 TO L
290  IF A%(I)  <  > 0 THEN  PRINT I
300  NEXT I
310  END
```

Listing 3: *SIGAV generates a simulated periodic waveform and, using integer arithmetic, computes the average shape of the wave.*

```
100  REM  *********
110  REM  * SIGAV *
120  REM  *********
130  HOME
140  PRINT "GENERATING DATA"
150  DIM D(4096),P(20)
160  FOR I = 1 TO 4096
170 D(I) = 0: NEXT I
180  FOR I = 3 TO 4096 STEP 7
190 D(I) = D(I) + 1
200  NEXT I
210 B$ =  CHR$ (7)
220  INPUT "READY ? ";A$
230  PRINT "START" + B$
240  GOSUB 1000
250  PRINT B$ + "END"
260  FOR I = 1 TO 7
270  PRINT P(I)
280  NEXT I
290  END
1000  REM  ******************
1002  REM  * SIGNAL AVERAGER *
1004  REM  ******************
1010  FOR I = 1 TO 7
1020 P(I) = 0
1030  FOR J = 0 TO 4089 STEP 7
1040 P(I) = P(I) + D(I + J)
1045  NEXT J
1050  NEXT I
1060  RETURN
```

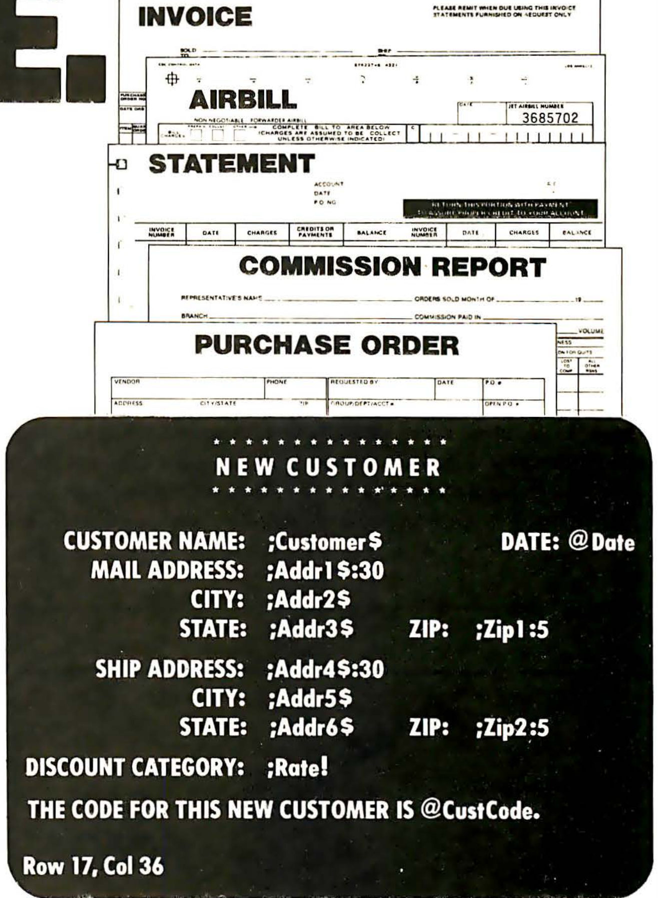
Listing 4: *KBAUD7 tests BASIC operations including integer arithmetic, subroutine call, and magnitude comparison.*

```
100  REM  **********
110  REM  * KBAUD7 *
120  REM  **********
130  HOME
140 B$ =  CHR$ (7)
150  INPUT "READY ? ";A$
160  PRINT "START" + B$
170 K = 0
180  DIM M(5)
190 K = K + 1
200 A = K / 2 * 3 + 4 - 5
210  GOSUB 280
220  FOR L = 1 TO 5
230 M(L) = A
240  NEXT L
250  IF K < 1000 THEN 190
260  PRINT B$ + "STOP"
270  END
280  RETURN
```

Listing 5: *SORT performs a sort of numbers into ascending order.*

```
100  REM  ********
110  REM  * SORT *
120  REM  ********
130  HOME
140  INPUT "READY ? ";A$
150 B$ =  CHR$ (7)
160  PRINT "START" + B$
170  DIM A(41)
180 X = 17
190  FOR I = 1 TO 40
200 X = X * 37
210 X = X - 100 *  INT (X / 100)
220 A(I) = X
230  NEXT I
240 N = I
250 S = 0
260  FOR I = 2 TO N
270  IF A(I - 1)  <  = A(I) THEN 320
280 Z = A(I - 1)
290 A(I - 1) = A(I)
300 A(I) = Z
310 S = 1
320  NEXT I
330  IF S = 1 THEN 250
340  PRINT B$ + "STOP"
350 K = 0
360  FOR I = 1 TO N
370  PRINT  TAB( 12 * K + 1);A(I);
380 K = K + 1: IF K < 3 GOTO 410
390 K = 0
400  PRINT
410  NEXT I
420  END
```

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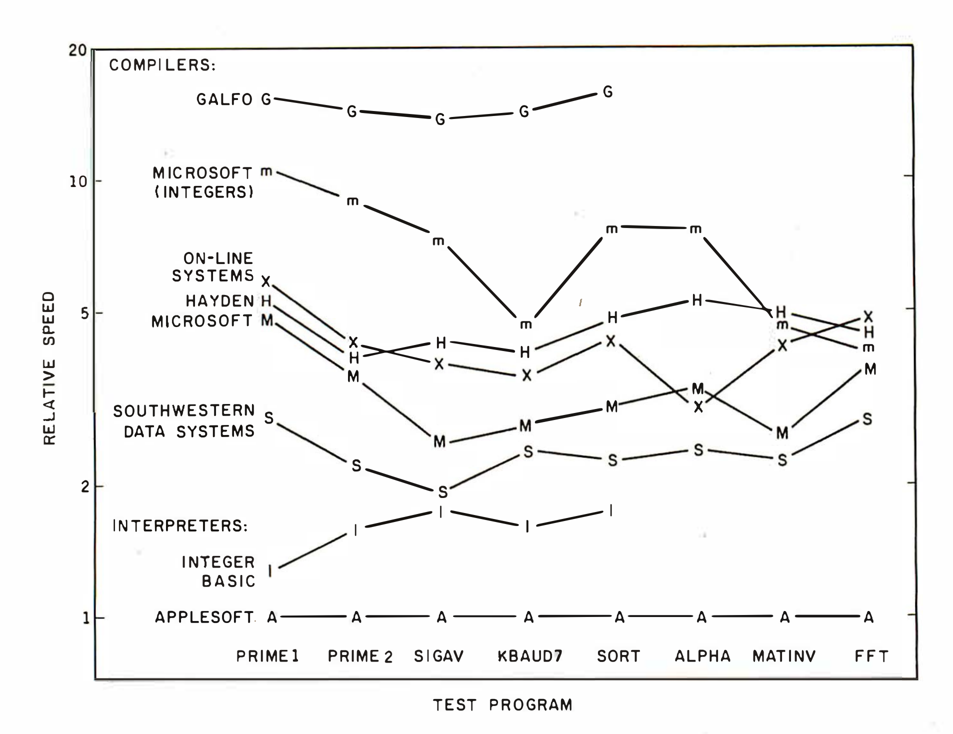


Figure 1: *Relative speed of eight test programs when run directly with the Apple computer interpreters and after compiling them with each of five compilers. The speeds are normalized to a value of 1.0 for the Applesoft interpreter. Two sets of data are given for the Microsoft compiler; those denoted by lowercase m were obtained by including an Integer declaration for all numeric variables used as integers.*

times faster than interpreted Integer BASIC, and 14 to 18 times faster than interpreted Applesoft BASIC. On the other hand, Integer BASIC does not allow string arrays and cannot be used easily for such purposes as inverting a matrix, computing a Fourier transform, or handling accounts-receivable-type functions. Such techniques as these, used frequently in scientific, statistical, and business applications, are better dealt with by Applesoft BASIC.

Of the Applesoft compilers, Microsoft's TASC produced the fastest code by a substantial margin for those programs with which its Integer option could be used effectively. The Hayden Applesoft Compiler and Expediter II were closely grouped in second and third place, followed by TASC (without invoking the Integer option) and Speed Star. For programs requiring floating-point calculations (such as MATINV and FFT), the performance of the compilers was more uniform, largely because all of them

Text continued on page 454

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Listing 6: *ALPHA performs a string comparison and sort.*

```
100  REM  *********
110  REM  * ALPHA *
120  REM  *********
130  HOME
140 B$ =  CHR$ (7)
150  INPUT "READY ? ";A$
160  PRINT "START" + B$
170  DIM A$(40)
180  FOR I = 1 TO 40: READ A$(I)
190  IF A$(I) = "ZZZ" GOTO 210
200  NEXT I
210 N = I
220 S = 0
230  FOR I = 2 TO N
240  IF A$(I - 1) < = A$(I) THEN 290
250 Z$ = A$(I - 1)
260 A$(I - 1) = A$(I)
270 A$(I) = Z$
280 S = 1
290  NEXT I
300  IF S = 1 THEN 220
310  PRINT B$ + "STOP": PRINT
320 K = 0
330  FOR I = 1 TO N
340  PRINT  TAB( 12 * K + 1);A$(I);
350 K = K + 1: IF K < 3 GOTO 380
360 K = 0
370  PRINT
380  NEXT I
390  END
400  DATA  NOTE,THAT,THE,ORDER,OF
410  DATA  SORT,CAN,BE,CHANGED,FROM
420  DATA  ASCENDING,DESCENDING,BY
430  DATA  MAKING,GREATER,THAN,TEST
440  DATA  IN,LINE,LESS,ALSO,SAYS
450  DATA  REPEAT,LOOP,FOUR,TIMES
460  DATA  FIVE,DUE,FACT,LOOKS,AHEAD
470  DATA  ONE,STEP
480  DATA  ZZZ
```

Listing 7: *MATINV inverts a 10 by 10 matrix.*

```
100  REM  **********
110  REM  * MATINV *
120  REM  **********
130  REM
140  DIM A(15,15),B(15,15),C(15,15)
150  DIM IK(15),JK(15)
160 B$ =  CHR$ (7)
170  HOME :NN = 10
180  PRINT "GENERATING 10 X 10 MATRIX"
190  FOR I = 1 TO NN: FOR J = 1 TO NN
200 A(I,J) =  RND (1)
210 B(I,J) = A(I,J): NEXT J
220  NEXT I
230  INPUT "READY ? ";A$
240  PRINT "START" + B$
250  GOSUB 10000
260  PRINT B$ + "STOP"
270  PRINT "CHECKING RESULTS ..."
280  FOR J = 1 TO NN: FOR K = 1 TO NN
290 S = 0
300  FOR M = 1 TO NN
310 S = S + A(J,M) * B(M,K): NEXT M
320 C(J,K) = S
330  NEXT K: NEXT J
```

Listing 7 continued on page 452



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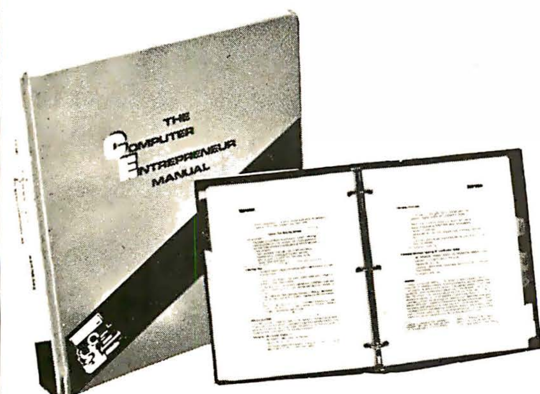
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Listing 7 continued:

```
340  PRINT : PRINT "DIAGONAL OF PRODUCT:"
350  FOR I = 1 TO NN
360  PRINT I; TAB( 6);C(I,I)
370  NEXT I
380  END
10000  REM  ***************
10010  REM  * MATINV SUBR *
10020  REM  ***************
10030 DET = 1
10040  FOR K = 1 TO NN
10050 AM = 0
10060  FOR I = K TO NN
10070  FOR J = K TO NN
10080  IF ( ABS (AM))  >  ABS (A(I,J)) GOTO 10120
10090 AM = A(I,J)
10100 IK(K)  = I
10110 JK(K)  = J
10120  NEXT J: NEXT I
10130  IF AM <  > 0 GOTO 10150
10140  PRINT "ZERO MATRIX -- ABORT": END
10150 I = IK(K)
10160  IF I = K GOTO 10220
10170  IF I < K GOTO 10060
10180  FOR J = 1 TO NN
10190 S = A(K,J)
10200 A(K,J)  = A(I,J)
10210 A(I,J)  =   - S: NEXT J
10220 J = JK(K)
10230  IF J < K GOTO 10060
10240  IF J = K GOTO 10290
10250  FOR I = 1 TO NN
10260 S = A(I,K)
10270 A(I,K)  = A(I,J)
10280 A(I,J)  =   - S: NEXT I
10290  FOR I = 1 TO NN
10300  IF I = K GOTO 10320
10310 A(I,K)  =   - A(I,K)  / AM
10320  NEXT I
10330  FOR I = 1 TO NN
10340  FOR J = 1 TO NN
10350  IF I = K GOTO 10380
10360  IF J = K GOTO 10380
10370 A(I,J)  = A(I,J)  + A(I,K)  * A(K,J)
10380  NEXT J: NEXT I
10390  FOR J = 1 TO NN
10400  IF J = K GOTO 10420
10410 A(K,J)  = A(K,J)  / AM
10420  NEXT J
10430 A(K,K)  = 1. / AM
10440 DET = DET * AM: NEXT K
10450  FOR L = 1 TO NN
10460 K = NN - L + 1
10470 J = IK(K)
10480  IF J  <  = K GOTO 10530
10490  FOR I = 1 TO NN
10500 S = A(I,K)
10510 A(I,K)  =   - A(I,J)
10520 A(I,J)  = S: NEXT I
10530 I = JK(K)
10540  IF I  <  = K GOTO 10590
10550  FOR J = 1 TO NN
10560 S = A(K,J)
10570 A(K,J)  =   - A(I,J)
10580 A(I,J)  = S: NEXT J
10590  NEXT L
10600  RETURN
```



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Listing 8: *FFT computes the discrete Fourier transform of a 64-point complex array.*

```
100  REM  *******
110  REM  * FFT *
120  REM  *******
130  DIM D(1024):IS =  - 1
140  HOME : PRINT "GENERATING DATA"
150 B$ =  CHR$ (7)
160 NZ = 64: PRINT "LENGTH:";NZ
170 P = 8: PRINT "PERIOD:";P:NF = NZ / P
180  FOR I = 1 TO NZ:J = I + I - 1
190 D(J) =  SIN (6.283185307 * (I - 1) / P)
200 D(J + 1) = 0: NEXT I
210  INPUT "READY ? ";A$
220  PRINT "START" + B$
230  GOSUB 10000: REM  CALL FOUR1(D,NZ,IS)
240  PRINT B$ + "STOP"
250  FOR I = 1 TO NZ / 2 + 1
260 J = I + I - 1
270 A = D(J)
280 B = D(J + 1)
290  PRINT I; TAB( 4);A; TAB( 20);B
300  NEXT I
310  END
10000  REM  *********
10010  REM  * FOUR1 *
10020  REM  *********
10030  REM
10040 P0 = 2:P3 = P0 * NZ:R3 = 1
10050  FOR I3 = 1 TO P3 STEP P0
10060  IF I3 >  = R3 GOTO 10100
10070 TR = D(I3):TI = D(I3 + 1)
10080 D(I3) = D(R3):D(I3 + 1) = D(R3 + 1)
10090 D(R3) = TR:D(R3 + 1) = TI
10100 P1 =  INT (P3 / 2)
10110  IF R3 <  = P1 GOTO 10140
10120 R3 = R3 - P1:P1 =  INT (P1 / 2)
10130  IF P1 >  = P0 GOTO 10110
10140 R3 = R3 + P1: NEXT I3
10150  P1 = P0
10160  IF P1 >  = P3 THEN  RETURN
10170 P2 = P1 + P1:TH = 6.283185307 / (IS * P1)
10180 S =  SIN (0.5 * TH):ZR =  - 2 * S * S:ZI =  SIN (TH)
10190 WR = 1.0:WI = 0.0
10200  FOR I1 = 1 TO P1 STEP P0
10210  FOR I3 = I1 TO P3 STEP P2
10220 J0 = I3:J1 = J0 + P1:TR = WR * D(J1) - WI * D(J1 + 1)
10230 TI = WR * D(J1 + 1) + WI * D(J1):D(J1) = D(J0) - TR
10240 D(J1 + 1) = D(J0 + 1) - TI:D(J0) = D(J0) + TR
10250 D(J0 + 1) = D(J0 + 1) + TI
10260  NEXT I3
10270 TR = WR
10280 WR = WR * ZR - WI * ZI + WR
10290 WI = WI * ZR + TR * ZI + WI
10300  NEXT I1
10310 P1 = P2: GOTO 10160
```

Text continued from page 448:
call on subroutines within the Applesoft interpreter for floating-point operations and especially for evaluating functions such as SQR, SIN, and LOG. For programs that use these functions, Hayden and Expediter II came out in the lead, marginally ahead of TASC, with Speed Star again bringing up the rear.

Compiled versions of very long programs, particularly if many variables are used, will generally exhibit an even faster relative speed, compared to the interpreted BASIC versions. This is because interpreters have to search through tables for variable names and line numbers whenever they are encountered during program execution. The compilers, on the other hand, perform the necessary lookups only at compilation time, inserting the appropriate addresses into the object code. We

note, however, that the relative speed rankings among the compilers is approximately the same because each compiler gains equally from this inherent advantage over the interpreters.

It is interesting to comment on two apparently anomalous dips shown in the data of figure 1; they reveal peculiarities of the TASC and Expediter II compilers. TASC (with the Integer option enabled for all variables) was not outstanding when running the KBAUD7 benchmark, compared to most of the other test programs, because KBAUD7 includes a division operation. As described in the TASC manual, all integer divisions are done by converting to floating point and back again. Therefore, in integer divisions, the program does not gain the speed advantage of true integer arithmetic. Expediter II performed relatively poorly in executing program ALPHA, which tests string handling. Unlike the other compilers, Expediter II allocates space for strings statically (at compilation time) rather than dynamically (at execution time), and its string-handling algorithm appears to be inefficient. (For those interested in details, Expediter II's performance on program ALPHA improved only slightly when its default string size of 40 characters was explicitly reduced to 10.)

Operation and Documentation

We found that all of the compilers were very easy to use on short programs. We had little difficulty in making them perform as advertised when compiling the benchmarks. Longer and more complicated programs may be a different matter, though. A compiled language has some intrinsic differences from an interpreted one—such as static, rather than dynamic, allocation of variable space and static definition of functions. In addition, cassette-tape operations are not supported by the compilers, in general, and Expediter II and Speed Star have not implemented the RESUME command. You should expect to have to make at least small changes in some programs to make them compile properly.

Galfo Systems' Integer BASIC Compiler: This compiler is furnished on two floppy disks. The "system" disk is in the standard DOS (disk operating system) 3.3 format and contains the 3.5K-byte run-time library and various utility programs. The second disk is in a nonstandard, copy-protected format and contains the compiler itself. Normal operating procedure begins with booting the Galfo system disk, which runs an appropriate Hello program and leaves the computer under control of the Integer BASIC interpreter. You then load the source program to be compiled (which must be an Integer BASIC file) and type "BRUN IBC" to begin the compilation process. On a one-drive system, you will be prompted appropriately for disk swaps.

IBC then asks three questions to establish compilation-time options. The most important of these options permits you to generate object code optimized either for fastest execution or for minimum program size. This feature is very nice; the fast code is very fast indeed but may be up to three times as long as the source program. In contrast, the compact code may actually be shorter than the source program. In our tests, the compact code executed only 10 to 20 percent more slowly than the fast code, though in some cases the speed penalty may be greater.

When compilation has finished, you can use the BSAVE command to save in binary format the object code on any standard DOS 3.3 disk. To run the compiled program, you use the BLOAD command to load in binary format the run-time library (if it is not already in memory) and then use the BRUN command to run in binary format the object file. Both the compiled code and the run-time library are relocatable by page and can be saved together as a single file if desired.

The Galfo instruction manual is thorough and complete, though not ornamentally packaged. (The 27 pages were reproduced from a dot-matrix printout.) An extensive section describes some very useful exten-

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sions to Integer BASIC. One of the nicest extensions is a set of high-resolution graphics commands similar in effect, though not identical in syntax, to those used in Applesoft. These features, together with its speed, would seem to make Galfo-compiled Integer BASIC an attractive language to use for developing high-speed graphics and game-playing programs.

Hayden Book Company's Applesoft Compiler: Furnished on a single 16-sector floppy disk (a 13-sector version is also available), the software is copy-protected and written to disk in nonstandard format. To use the compiler, you boot the disk; the program then asks for the name of an Applesoft source file and prompts you to swap disks (if necessary for single-drive systems). It then requests an object filename, suggesting a default by preceding the source filename with BIN., as in BIN.PRIME1. Compilation then begins, the system agreeably keeping you posted on what it is doing by displaying flashing messages such as LOADING COMPILER, PARSING, SAVING OBJECT, and so on. The automatically saved object file includes a copy of necessary routines from the 3.3K-byte run-time library. To execute the program you press Reset, reboot the system, and use the BRUN command to run the saved object file.

The Hayden compiler has some useful features that help to streamline its generated code. Expressions and even subexpressions with integer operands are evaluated as far as possible with 16-bit arithmetic routines. Also, the compiler generates array-lookup vectors for multidimensional arrays, thereby avoiding many time-consuming multiplications when array elements are referred to at execution time. Several source programs can be compiled separately. They then call each other as modules or are called by interpreted Applesoft programs. However, the mechanism for sharing variables between programs is somewhat cumbersome and error prone.

The Hayden instruction book is professionally packaged in an attractive three-ring binder. The documentation is clear and informative, though perhaps somewhat sparse.

Microsoft's TASC: This compiler is furnished on a single 13-sector floppy disk. With a DOS 3.3 system, you must use the program Muffin to copy the five TASC files onto your own standard 16-sector disk. If you have only a single disk drive, you than have the desirable advantage of being able to put everything (compiler files, run-time library, source files, and object files) on the same disk, so that no swapping is required.

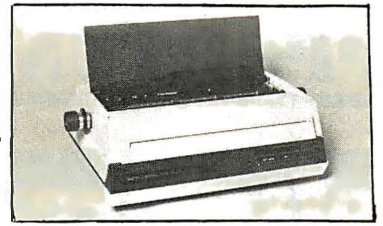
To compile a program, you type "RUN TASC." You will be asked for a source filename (e.g., PRIME1) and an object filename (which defaults, in this case, to PRIME1.OBJ). The compiler asks two questions that permit nonstandard memory-address assignments for the object code and nonstandard options concerning listings, error handling, and so on and then proceeds to compile the program. TASC is the slowest compiler we tested; very long programs required 10 minutes or more to compile. To run the compiled code, you must use the BLOAD command to load the run-time file and then use the BRUN command to run the object file.

Microsoft's instruction manual is superb. It is packaged in a handy loose-leaf binder and is 97 pages long. Chapters are arranged in order of increasing complexity, starting with a tutorial on what compilers can do. The manual gives detailed examples using TASC with a graphics demonstration program on the disk and covers advanced programming considerations such as optional use of the very powerful Integer declarations. The final chapter describes in detail the internal workings of the TASC compiler, including the interesting information that TASC was written in Applesoft and used to compile itself! (No, the source code is not included on the disk.) The Microsoft manual is the only one of the five to include an extensive index. It is a very professional piece of work.

On-Line Systems' Expediter II: Both 13- and 16-sector versions are furnished on a single floppy disk and

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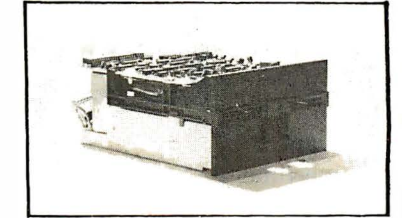
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written in a nonstandard format. To compile a program, you boot any standard DOS disk, load the desired Applesoft program, and type "BRUN EXPEDITER," changing disks if necessary before pressing Return. The compiler asks whether you want to accept the default compilation-time options and allows you to change them if desired. It then proceeds to compile the program. When compilation is finished, the Applesoft program has been replaced in memory by a single-line program, a CALL instruction to the starting address of the compiled code. The program can be run immediately or saved on disk if desired. The saved program will appear in a DOS catalog display as an Applesoft program, but actually it contains the single CALL statement together with the binary object code and the 2.3K-byte run-time library.

The Expediter II manual is paper covered, printed on gray stock, and adequate but not extensive. It contains little tutorial material, though we believe a first-time user will probably be able to understand it.

Southwestern Data Systems' Speed Star: This compiler comes on a 16-sector standard-format disk. Operation requires that a hardware key be plugged into the Apple paddle port. (The paddles can still be connected, piggyback style, because the key has a socket on its top.) To use Speed Star, you boot the disk or type "BRUN SPEEDSTAR." The compiler is loaded into memory, the HIMEM pointer is reset to protect the compiler, and you are left with standard DOS and the Applesoft interpreter in command. You may then load or otherwise enter any Applesoft program; to compile it you type the ampersand character (&), optionally followed by parameters specifying nonstandard addresses, etc. For programs of modest size, everything can be in RAM—Speed Star itself, the program to be compiled, and the generated object code—so no disk accesses are required, and compilation is extremely fast. These programs compile in a second or two! Very long programs may not compile at all, however, because of memory limita-

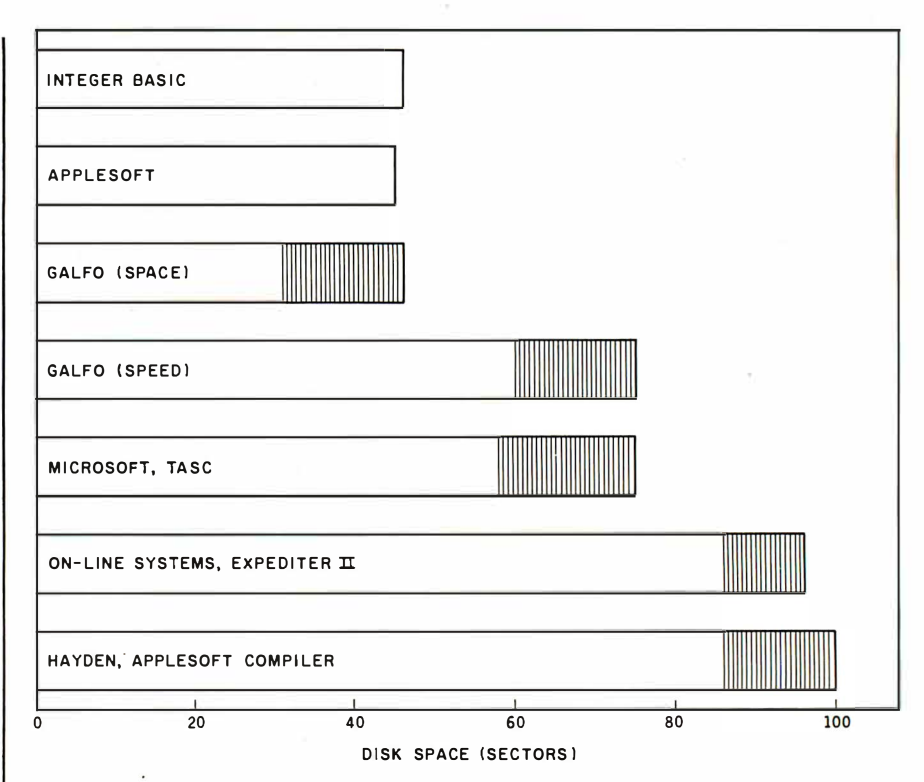


Figure 2: *Comparison of disk storage requirements for a version of the Yahtzee game, using the two interpreted BASICs and four of the five compilers. Shaded segments of the bars represent the run-time libraries required by each system. Both the fastest-execution and the minimum-program-size options for Galfo Systems' Integer BASIC Compiler are shown. As described in the text, the test program was too long to be compiled by Speed Star.*

tions. This problem can be reduced by using a compile-to-disk option or by using a memory-efficient segmented version of the compiler (see following section). With the segmented version, compilation speed is comparable to that of the other compilers. To run a compiled program already in memory, you simply call the starting address of the object code. The object program may be saved in binary format in the usual way, either with or without the run-time library.

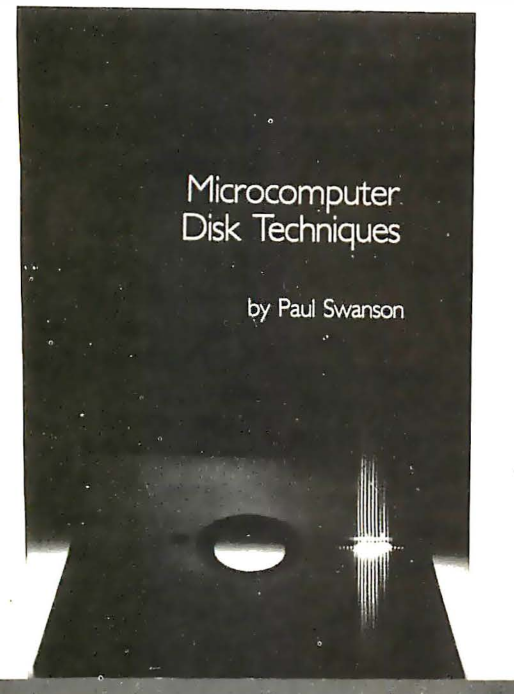
Code Expansion

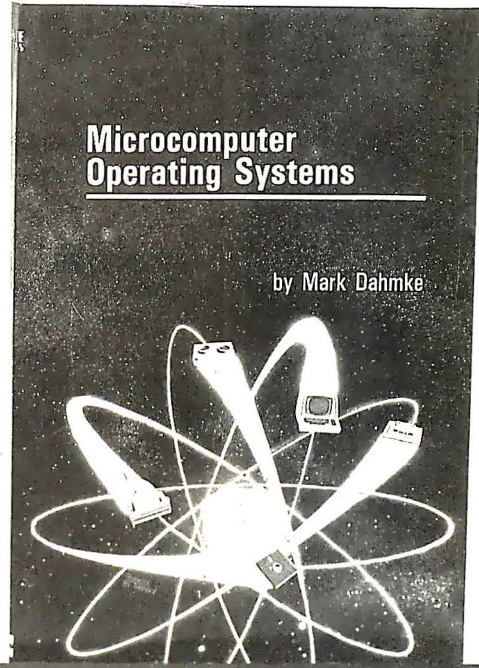
In order to make an objective comparison of the memory requirements for code produced by the different compilers, we used a game similar to Yahtzee, which was programmed originally in Integer BASIC and translated directly into Applesoft. Except for small syntax differences, the two versions were essentially identical; a player could not tell which one he was using. As shown at the top of figure 2, the two versions of the BASIC source code have nearly identical disk-storage requirements: 46 sectors for Integer BASIC and 45 sectors for Applesoft. We produced compiled versions of the program, tested each one for correct execution, and then checked the length of the object code. The results are shown in figure 2.

The clear winner of the race to produce compact code was the Integer BASIC Compiler of Galfo Systems, using its optimize-for-space option. Its object code required only 31 sectors, exclusive of the necessary 15-sector run-time library. When optimized for execution speed, the object code nearly doubled to 60 sectors (plus 15 for the library); however, the other Applesoft BASIC compilers took up equal amounts or more of memory. TASC required 75 sectors, Expediter required 96, and the Hayden compiler needed 100 sectors!

We were unable to compile Yahtzee using Speed Star. Even when using the segmented version of the compiler together with the compile-to-disk op-

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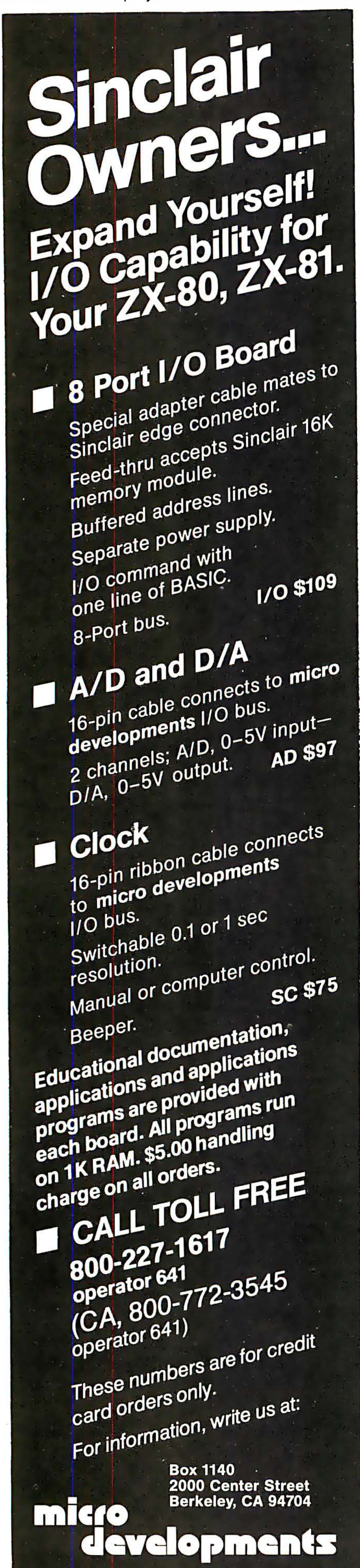
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tion and after reducing the source code size to 38 sectors (by removing the game's instructions and many REM statements), we were confronted by out-of-memory compiler errors. Speed Star could probably handle Yahtzee if you divided the game program into two or more separately compiled segments, as described in the next section.

Chaining and Overlays

Each of the compilers allows some kind of chaining from one program segment to another to permit very long programs to be run even though all of the object code cannot fit simultaneously into memory. Variables can be preserved, if desired, to allow access by the next chained program segment. The ease of accomplishing this task varies quite a bit among the compilers. Galfo's Integer BASIC, Hayden's Applesoft Compiler, and Southwestern Data Systems' Speed Star all allow you to disable the variable-clearing function when a new segment starts executing. However, with these compilers, all of the program's variables are, in effect, in a "global" common area, stored in the order in which they are used in the program. It is your responsibility to keep the desired equivalences straight, and this is not always an easy job. Expediter II and TASC, on the other hand, provide active REM statements that allow you to declare particular variables as "global" and others as "local." This procedure makes chaining much easier. Speed Star has a nice feature that makes it easy to call a compiled module from an interpreted Applesoft program and to pass parameters to it in a very convenient way. Unfortunately, only simple variables can be passed—not arrays—and the transfer path is a one-way street. Moving results back to the interpreted program is considerably more complicated.

In summary, by putting effort into reading the manuals and trying things out, you can accomplish almost any kind of overlaying or chaining of modules with any of these compilers, but only Expediter II and TASC make the job easy.

Conclusions

All of the compilers perform essentially as advertised, and all provide very worthwhile improvements in execution speed. Our overall recommendations can be summarized as follows:

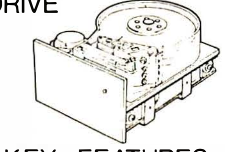
- Galfo Systems' Integer BASIC Compiler is the execution speed champion, by a significant margin, and also produces the most compact object code. It is our first choice for all applications where its (extended) Integer BASIC can be used.
- For more general use and for all applications in which floating-point operations are essential or desirable, our first choice is Microsoft's TASC. Its easy-to-use integer declaration makes some programs execute significantly faster than they do with any of the other Applesoft compilers. In addition, its compiled code is significantly more compact, and its user's manual is outstanding. Other less quantitative features also seem to favor TASC, including the obvious convenience of its global common declarations and its standard, unprotected disk format.
- Both Hayden's Applesoft Compiler and On-Line Systems' Expediter II each produced the fastest code in at least one of our tests, and both are very serviceable products. We fault them primarily for being somewhat less convenient to use than TASC, requiring much disk swapping on a one-drive system and (for the Hayden Compiler) requiring a system reboot before every compilation. It is worth noting that at the present list price of $100, Expediter II is an excellent buy.
- It is a pity that Speed Star's object code is not faster; its convenience for modest-sized programs is second to none. Speed Star can reside in your Apple's memory in a more or less transparent way and can do its job on demand in just a few seconds. However, for most of our benchmark programs, its execution speed is only 2 or 3 times faster than interpreted Applesoft BASIC, as compared to 4 to 10 times for the other compilers. In some applications, the relatively poor speed ranking might be outweighed by the desirable convenience factors. ■

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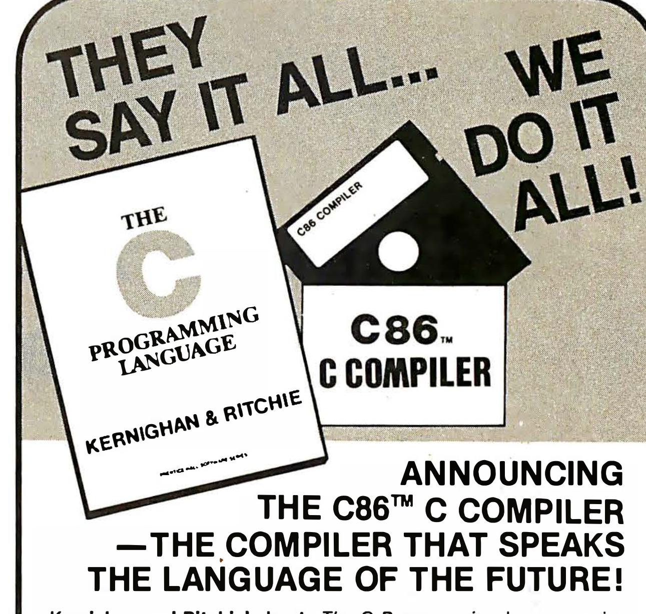
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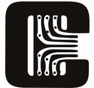
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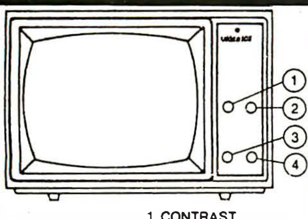
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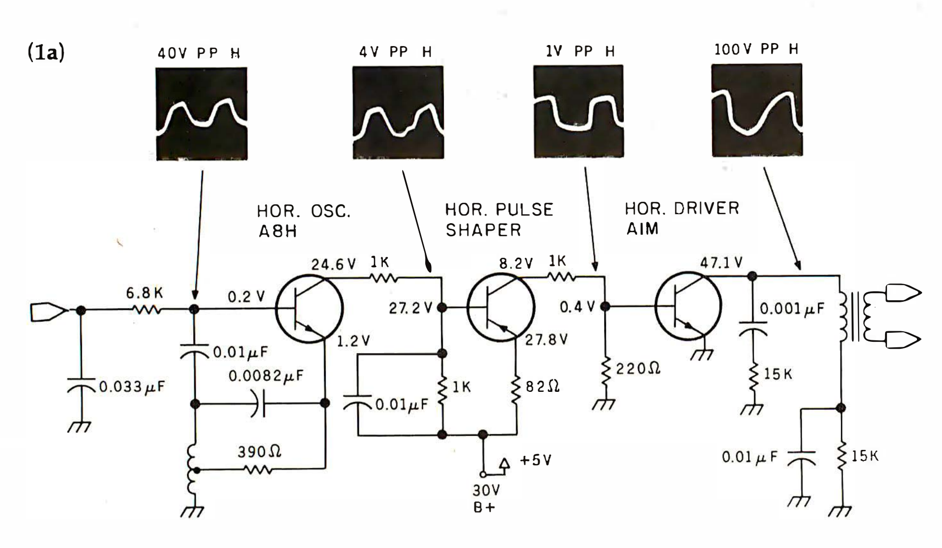
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Digital Troubleshooting with Signature Analysis

A look inside Hewlett-Packard's HP-5004A.

Steven C. Piubeni
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(1a)



(1b)

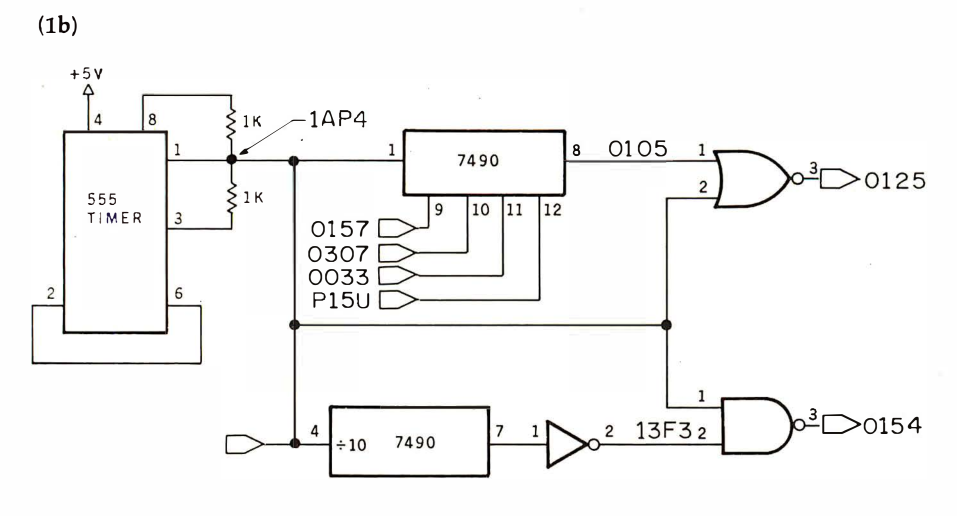


Figure 1: *Comparison of troubleshooting techniques. Figure 1a shows a standard schematic diagram, annotated by the manufacturer with analog waveforms. Figure 1b shows an example of a digital circuit and the attendant signatures used for analysis.*

In the earlier days of electronics, signal tracing was the most common method of troubleshooting analog circuits. Most of the schematics had pictures of the expected waveforms at various test points (see figure 1). This allowed a technician with limited exposure to the product to recognize a faulty signal and repair the problem quickly. With the birth of digital electronics, however, came the complex data streams associated with bus-oriented computers. The complexity of these waveforms (often it is the timing relationship between a number of signals that is important) makes it impossible to give the inexperienced technician a visual indication of what the signals are supposed to look like.

Because of these complex circuits, most repairs made in the field have involved "board swapping." This is an expensive method of troubleshooting systems because a large inventory of boards must be kept on hand, and shipping them back to the manufacturer drives up the cost and also increases repair time.

The Hewlett-Packard HP-5004A Signature Analyzer offers a solution to all the problems discussed above. It allows the manufacturer to revert back to the simple yet efficient troubleshooting method of signal tracing. The analyzer looks at the data stream and displays a 4-bit hexadecimal *signature* (see figure 1b).

A signature is used to verify that

the data stream is correct. For example, if a signature at a particular point in a circuit is known to be 12PU; and if when a malfunctioning circuit board is probed, the signature at that point reads 3256, the problem with that board lies somewhere in that circuit path. If, when that test point is probed, the signature reads 12PU, that circuit is correct, and the problem lies somewhere else.

Hewlett-Packard's Analyzer

The HP-5004A Signature Analyzer weighs 5.5 lbs. The case is constructed of white "high-impact" plastic and has a 4-digit nonstandard hexadecimal display. A pouch on the top of the case is used for storing the *signal pod* and the *data probe*. The hexadecimal display's character set is: 0,1,2,3,4,5,6,7,8,9,A,C,F,H,P,U. Hewlett-Packard claims this nonstandard hexadecimal character set is used to provide clarity between characters. I see it, however, as a cost-reducing measure because 7-segment displays are less expensive than true hexadecimal displays. The display provided is adequate and, I must admit, the approach is clever.

The signal pod is made up of four wires with special "terminal-grabbing" connectors. Each wire is color coded for easy identification. The four pod leads hook onto the unit being tested. These leads carry the signals Start, Stop, Clock, and Ground. Start and Stop determine the period for which the signature is to be taken. Clock strobes the data into the analyzer synchronously. Ground provides a reference between the analyzer and the unit being tested. The analyzer uses a single hand-held data probe to obtain the signatures. Since the probe contains an LED (light-emitting diode), it can double as a logic probe.

The front panel of the analyzer has six push-button switches: Line, Start, Stop, Clock, Hold, and Self Test. Line is used to turn the analyzer on or off. The Start, Stop, and Clock switches set up triggering on either rising or falling edges. Pressing the Hold switch causes the analyzer to sample only the first available signature. This is similar to using an oscilloscope in the single-sweep mode. Self Test is used to determine if the analyzer is functioning properly.

The Construction of a Signature

Signature analysis provides no diagnostic information; it is simply a comparison method of troubleshooting. Two popular theories concern implementing signature analysis. One is *transition counting*; the other is *pseudorandom-number generation*. Both methods require a Start, Stop, and Clock for proper control of the signature. (Clock is required to strobe the data stream into the counting circuitry in a synchronous fashion.)

In transition counting, a counter is initialized with a count of 0. The count will be incremented by 1 every time the Clock signal occurs *and* the data bit present on the probe differs from the data bit present during the previous Clock signal. Looking at how transition counting works, we see a situation in which a count could be ambiguous: when a string of 3 bits has complementary values on each

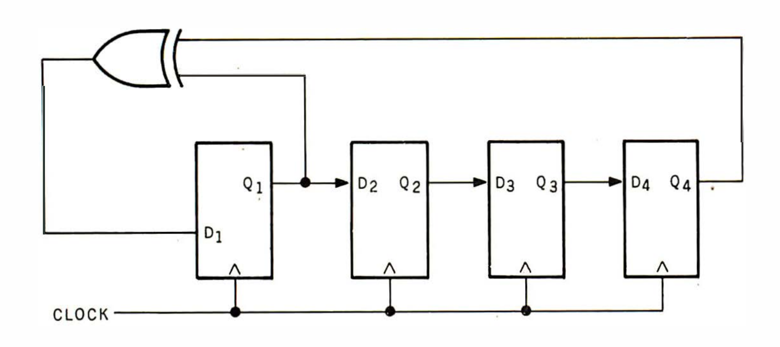


Figure 2: *Model pseudorandom binary-number generator. This circuit produces the sequence of binary numbers shown in table 1, with just a simple shift register and an Exclusive OR gate.*

		Q1*	Q2	Q3*	Q4	D1 = Q1 + Q4
Initial count→	T0	1	0	0	0	1
	T1	1	1	0	0	1
	T2	1	1	1	0	1
	T3	1	1	1	1	0
	T4	0	1	1	1	1
	T5	1	0	1	1	0
	T6	0	1	0	1	1
	T7	1	0	1	0	1
	T8	1	1	0	1	0
	T9	0	1	1	0	0
	T10	0	0	1	1	1
	T11	1	0	0	1	0
	T12	0	1	0	0	0
	T13	0	0	1	0	0
	T14	0	0	0	1	1
Pattern repeats→	T15	1	0	0	0	1

*Feedback taps

Table 1: *The states of the various bits of the shift register in figure 2.*

end. For example, let's compare the counts produced by the binary bitstream sequences 001 and 011.

As previously mentioned, the count will be incremented every time the previous bit differs from the present bit. Let's assume that the sequences are synchronized with the clock. The analyzer looks at the first bit of sequence 001 and compares it to the second. Because the first 2 bits are different, the count is incremented. The analyzer will then proceed to look at the second and third bits. Since they are identical, the count will remain at 1. Now let's look at sequence 011: the analyzer looks at the first and second bits. Since they are identical, the count will remain at 0. The analyzer will now look at the second and third bits and see that they are complementary. The count will be incremented to 1. Notice that the two sequences produced the same signature. This method leads to ambiguity, and thus should not be implemented.

Pseudorandom Binary Sequences

Robert Frohwerk (who did the design work for Hewlett-Packard on signature analysis) came up with an alternate choice called PRBS (pseudorandom binary sequences). Although the term sounds quite complicated, it is relatively easy to understand with the aid of figure 2.

Only two different types of components are required to implement PRBS signature analysis: the Exclusive OR gate and the D-type flip-flop. The Exclusive OR gate acts as a modulo-2 adder; the flip-flop performs the function of a shift register when hooked in series with other D-type flip-flops.

By taking the outputs of different flip-flops, Exclusive ORing them together, and feeding the result back into the shift register, we produce a pseudorandom sequence. Initially, the shift register must be preset to 0001. This enables the PRBS generator to run freely. If the count were set to 0000, there would be no feedback, and the generator would not run.

In table 1, we see the output of a PRBS generator in free-running mode. After one clock cycle, the first bit is loaded into the shift register. If the outputs of each flip-flop were visible, we would see (in order) 1000. On the next clock cycle, the output of the first flip-flop will be passed along to the second. The input of the first flip-flop will now be determined by the output of the Exclusive OR gate.

Checking table 1, we see that at T1 the output of bit 1 is 1 and the output of bit 4 is 0. Therefore, the feedback loop will load a 1 into the first flip-flop of the shift register. After the sixteenth clock pulse (T15), the pattern repeats, providing us with a cyclic counter capable of compressing large data streams and providing an accurate signature.

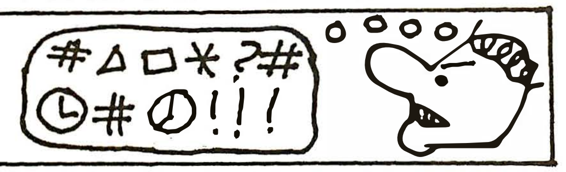
How Is It Really Done?

Now that we have looked at a *model* PRBS generator, let's discuss the PRBS generator circuit used in the HP-5004A. The HP-5004A uses a 16-bit shift register. This allows for plenty of accuracy, which will be discussed shortly. The four feedback taps are from bits 7, 9, 12, and 16 of the shift register. (Most microprocessors and other digital equipment use data related by powers of 2. By spacing the taps unevenly, we guarantee picking up the maximum number of errors. See table 2.)

When first looking at the circuit detailed by Hewlett-Packard (see figure 3), it would appear as though the four feedback taps are fed into a four-input Exclusive OR gate. After checking several data manuals published by Texas Instruments, Signetics, National Semiconductor, and Fairchild, I could not find such an integrated circuit. I constructed an

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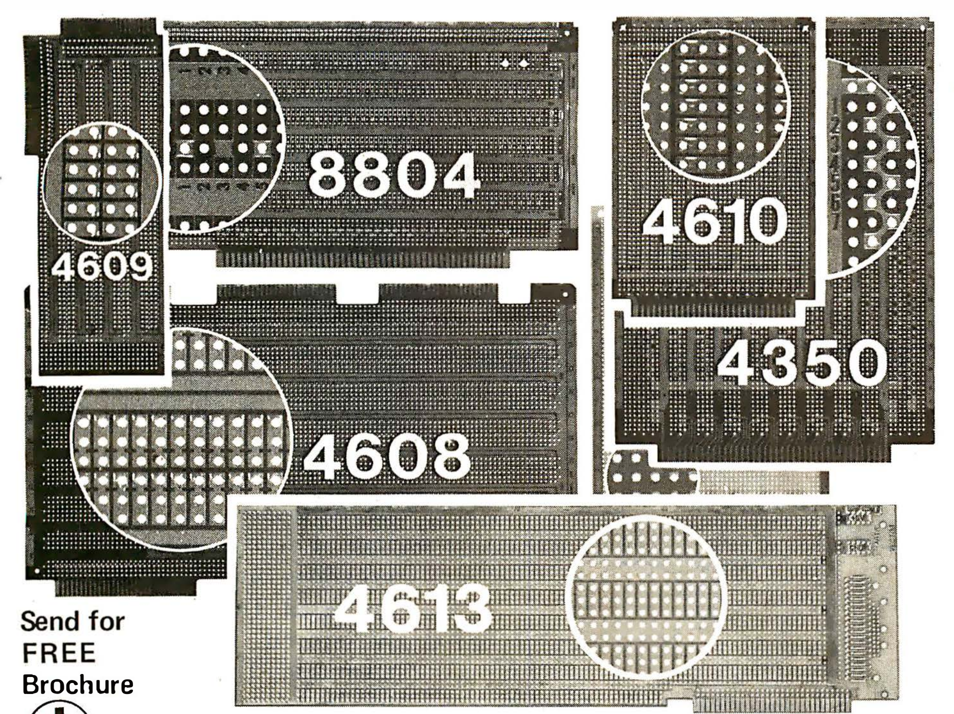


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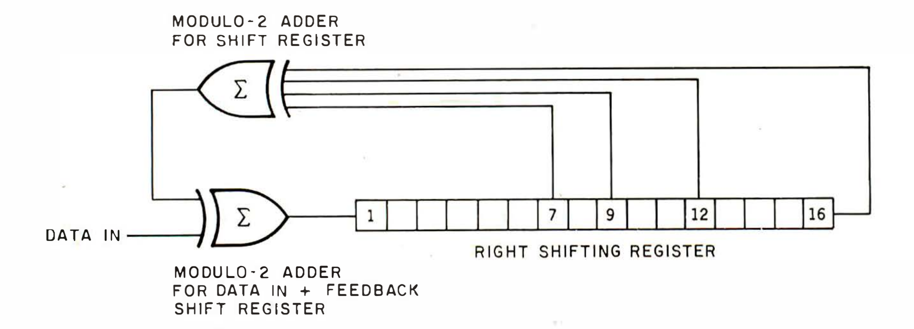


Figure 3: *Pseudorandom-number generator as used by Hewlett-Packard in its HP-5004A Signature Analyzer. The four-input Exclusive OR gate is made from a parity generation/checking device.*

(4a)

FOUR-INPUT EXCLUSIVE OR GATE
BIT 16
BIT 12
BIT 9
BIT 7
DATA IN

(4b)

UNUSED BY HP-5004A
+5V
ALWAYS HIGH
BIT 16
BIT 12
BIT 9
BIT 7
DATA IN

Figure 4: *Two methods of using a four-input Exclusive OR device. Figure 4a is the equivalent of figure 3, with the internal architecture displayed. Figure 4b shows the insides of the 82S62 device used by Hewlett-Packard.*

equivalent circuit employing a 7486 two-input Exclusive OR gate (see figure 4a).

When I checked the actual HP-5004A circuit board, I found that an 82S62 parity generator/checker was being used as a four-input Exclusive OR gate and a two-input Exclusive OR gate. In figure 4b, I show the architecture for implementing the four-input Exclusive OR gate. An advantage to using this device is that the data can also be Exclusive ORed with the modulo-2 sum of the feedback taps from the shift register. Although you may find the use of one integrated circuit as opposed to another insignificant, it is interesting to note the engineering involved in obtaining the maximum performance at the minimum cost.

Because of the unique design of the circuit, the PRBS generator will always pick up a single-bit error. To calculate the chance of the generator missing multiple bits, the following equation can be used:

$$\text{Prob} = (1/2)^n$$

Prob is the probability of an error not being detected; n is the number of bits in the PRBS generator. For the HP-5004A, with 16 bits arranged in a PRBS design, the error rate is 16 ppm (parts per million), or 1 in 65,535. This is certainly acceptable for most applications.

Analyzing Signatures

Up to now, we have discussed the need for signature analysis, what a signature actually is, and the different methods of obtaining a signature. We will now briefly focus on *using* signature analysis, an overview of the HP-5004A, and how signature analysis will affect the microcomputer market.

The signature analyzer has very little hardware and software. Therefore, it depends upon diagnostic test programs running on the system being tested. These programs are usually stored in ROM (read-only memory). The diagnostic program toggles all the address lines, data lines, I/O (input/output) ports, and different enable lines. With the test

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T19	0	1	0	1	0	0	1	0	1	0	1	1	0	1	0	0
T18	1	0	1	0	0	1	0	1	0	1	1	0	1	0	0	1
T17	0	1	0	0	1	0	1	0	1	1	0	1	0	0	1	1
T16	1	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1
T15	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0
T14	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0	0
T13	1	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0
T12	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0
T11	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0
T10	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0
T9	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0
T8	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
T7	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0
T6	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
T5	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
T4	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
T3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
T2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Feedback taps

Table 2: *The states of selected bits of the shift register in figure 3.*

program adding about 2 percent of firmware to the system, the overhead is minimal.

When a computer system is down, the technician simply plugs in a test ROM and hooks the signature-analyzer pod to the designated terminals for Start, Stop, Clock, and Ground. All that's required now is to take signatures and compare them to the schematic. Once the erroneous signature is found, the signal path is traced back to the faulty component.

Another valuable use for a signature analyzer is to test ROMs out of a system. By building a counter equal to the number of addresses in the ROM, and allowing the counter to run, it will address each location and create a data stream in which signatures could be recorded. The questionable ROM signatures could be compared to the standard signatures to see if they coincide. This approach could also be applied to random-access read/write memory, if read/write circuitry was installed.

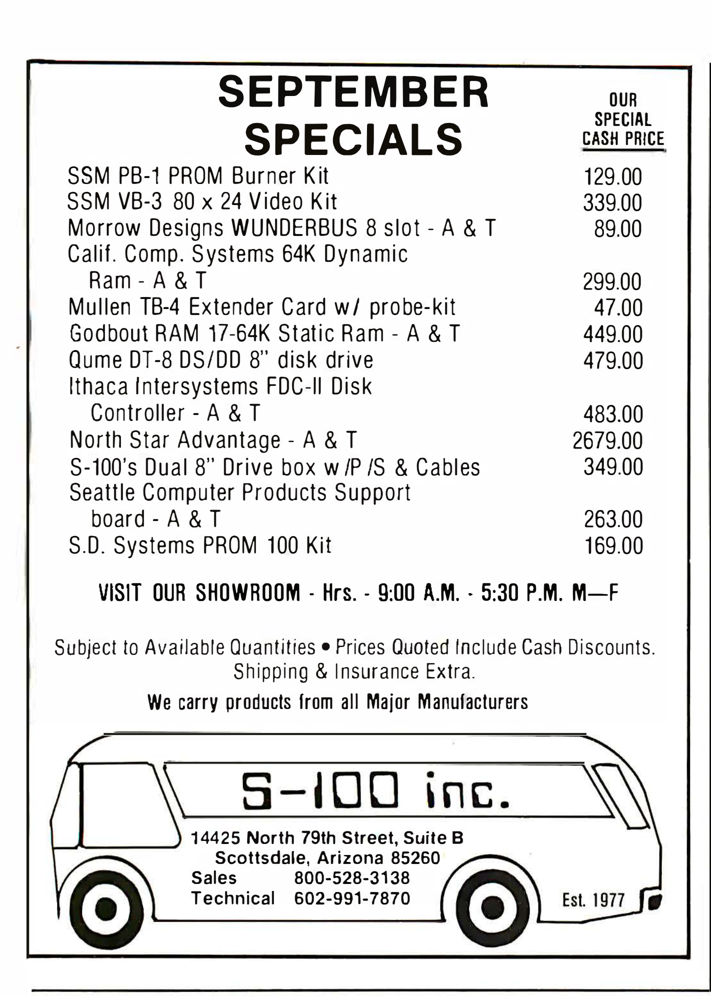
Conclusions

The application of signature analysis in the microcomputer market will become more evident because it employs a nontechnical approach to troubleshooting complex circuits. By applying this technique on the manufacturing level, an untrained individual can do the job previously held by a highly skilled technician. The use of signature analysis could also eliminate the need for multiple, replaceable boards because field diagnostics could be made down to the component level. Both of these cost-reducing measures will help bring down the already falling price of computers, thus bringing more consumers into the marketplace.

In the years ahead, we will see signature analysis seeping into the computer market, just as we have seen the microprocessor become the standard of computer circuit design. ■

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2. Gordon, Gary and Hans Nadig. "Hexadecimal Signatures Identify Trouble-Spots in Microprocessor Systems." *Electronics*, March 1977.
3. *Hewlett-Packard Operating and Service Manual*, March 1977.





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The awkwardness of using traditional text editors is a constant source of frustration for many computer users. The use of special sequences of characters to manipulate and display text just isn't natural. It would be much easier to manipulate text if an editor duplicated the advantages of a typewriter; namely, the text is always visible in its latest form and each press of a key is a complete operation. This two-part article presents such a text editor and it is a dramatic improvement over traditional text editors.

Text editing, which is nothing more than the creation and modification of textual material (such as computer programs, letters, and manuscripts), is the cornerstone of computer applications. But it is unfortunate (and ironic) that the text editor is often the most awkward program to use. Fortunately, improvements in the convenience of editing are practical and are becoming common. Such improvements increase productivity, reduce frustration, and make computers more accessible to the average person. The text editor presented here offers these advantages.

I call my text editor the Video-Display-Oriented Text Editor (VDO text editor). Part 1 of this article describes the design and use of this editor and part 2 contains the listing of the program source code (in assembly language for Z80- and 8080-based microcomputers). The comments within the listing will allow readers to implement it on their systems. Also included in part 2 are sample I/O (input/output) routines that interface the program with the peripheral devices of the author's system.

This text editor makes computers more accessible to the average person.

A Brief Description

The most important feature of the VDO text editor is that, in the normal editing mode, the video-display screen contains only the text. There is no need for instructions to appear on the screen because pressing a single key immediately changes the text both internally and on the screen. Although this concept is simple, its practicality is impressive. Consider what it would be like to have 16 or 24 lines of text visible on your screen and to see the text updated *as soon as you press a key*.

In order to make this scheme practical, it must be easy to quickly repeat the editing operations any number of times. The most convenient way of doing this is to hold down the appropriate key while the editor quickly repeats the indicated operation and release the key when it has been repeated enough. To differentiate between a one-time operation and a repeated operation, a time delay is included between the first execution of the operation and the beginning of the fast repetitions. This feature (included in some computer terminals and electric typewriters) is referred to here as the *automatic repeat feature*.

The automatic repeat feature is of central importance to the use of the VDO text editor, so I will explain its operation from a user's point of view. When a key is initially pressed, the appropriate editing operation is executed. If the key is released within one second, nothing further happens. However, if the key is still depressed one second after it was first pressed, the editor automatically repeats the same operation at a fast rate—say 10 times per second. As the repetitions

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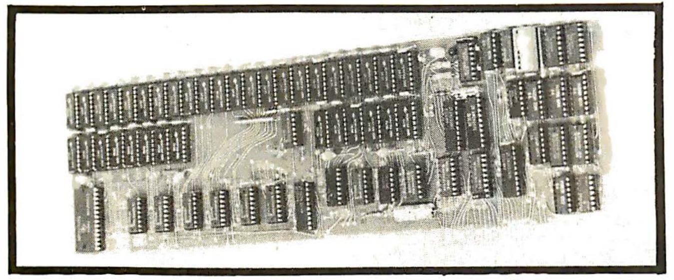
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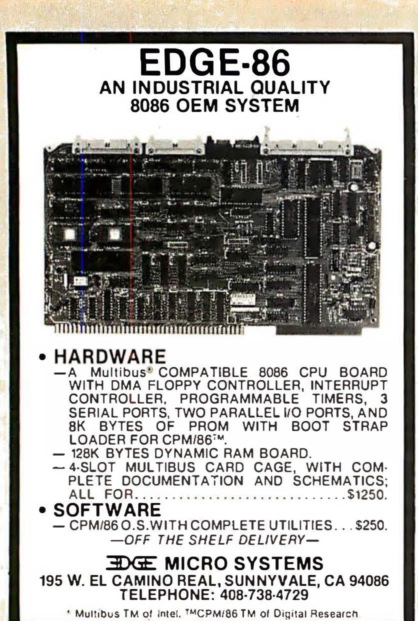
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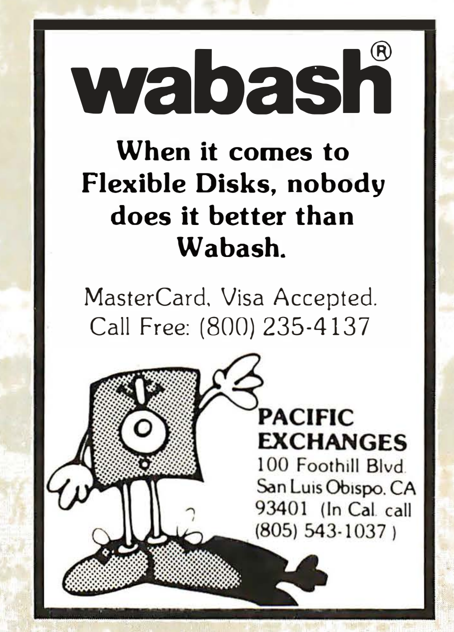
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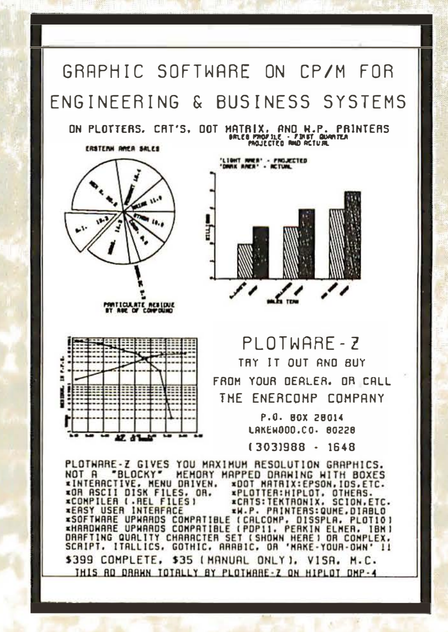
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continue, they become even faster—to a limit. Finally, when the key is released, the repetitions stop.

A major advantage of the automatic repeat feature is that there is no need to count the number of times an editing operation needs to be done—it's as simple as holding down a key until you *see* that the text has been changed to your liking. If the repetitions are too fast for the key to be released at the right moment, the key can be released early and a few extra taps of the key complete the change.

Compared to Traditional Editors

Let's now compare its use with traditional text editors. Unlike traditional editors, the VDO text editor does not require a "command line" of characters to indicate what operations are to be done, how many times they are to be repeated, and what portion of the text is to be displayed. This greatly reduces the number of keystrokes (don't forget those "delimiters" normally needed), eliminates the need to remember special codes, eliminates the need to count characters or lines, eliminates the need to choose unique character strings (used to locate specific areas of the text), and eliminates the need to remember what mode the editor is in. There is also no need to remember where the cursor is and what changes have already been made.

With such distinct advantages, why hasn't this type of text editor become more common? The first reason is that the need to frequently and immediately redisplay a full page of text consumes a great deal of extra computer time and requires that the editing program be given first priority in situations where multiple tasks are being executed. This makes it unacceptable for timesharing systems. Another reason is that the speed of the display device must be great enough to handle a full-screen update within a fraction of a second, making all serial terminals and some microcomputer display devices unacceptable. But many microcomputers do not have these limitations.

So why didn't this form of text editing become prominent on microcomputers earlier? Apparently, an

assumption is often made that microcomputers are simply scaled-down versions of larger computers, suitable only for scaled-down versions of traditional software. But by breaking away from tradition, microcomputer users can benefit from unique advantages.

I don't want to speculate which microcomputers are compatible with this editor, but my Digital Group microcomputer accommodates it without any hardware modifications. Specific comments on the video-display and keyboard requirements are included later, but for now it is sufficient to say that this editor can be implemented on many microcomputers without any hardware modifications.

Important Concepts

In order to have a more concrete understanding of what it is like to use this text editor, I will present a simple example; but first, it is necessary to briefly explain three additional concepts central to its operation.

As in all text editors, the *cursor* is important. The cursor is a *pointer* to any location in the text. In this editor, the cursor is a special symbol (a right arrow in my version). The importance of the cursor is that it points to the position in the text where insertions will occur if an insertion operation is used, or it indicates which part of the text will be erased if an erasure operation is used. Also, since the cursor is always visible, its location determines which part of the text appears on the screen.

This editor is *character-oriented* rather than *line-oriented*. A character-oriented editor is more convenient to use because it allows characters within a line to be manipulated in a straightforward manner. In contrast, the smallest unit a line-oriented editor can operate on is a full line—although the careful use of search-and-replace operations allows changes to be made within a line without retyping it. Another advantage of character-oriented editors is that carriage returns (end-of-line indicators) can be inserted and erased—especially useful when a portion of a line needs to be moved to an adjacent line.

So far, I have implied that all the editing operations are associated with their own keys. However, such an approach is not practical due to the limited number of keys available. Since some of the operations do not require use of the automatic repeat feature, they are accessed via a menu mode—which requires *two* keystrokes. The first key pressed is the ESC (escape) key. A menu of available options, including their associated letters or symbols, appears on the screen:

T Top
B Bottom
L Load
S Save
H Start Here
C Copy Part
* Erase Part
! Erase All
P Print

(Note that the two erasure operations make use of shifted characters to reduce the chance of erasing large portions of the text accidentally.) Pressing one of these keys causes the associated editing operation to be executed immediately. When the operation is done, the text reappears. This method is convenient to use because visual feedback is provided when the ESC key is pressed and because the key assignments are visible when needed.

An Example of Its Use

We will now venture through a simple example of text editing that illustrates both the concepts already presented and the use of the editing operations yet to be explained.

Upon entering the editor, the screen is blank except for the cursor in the upper-left corner of the screen. Since you wish to edit an existing file, start by pressing the ESC key. A menu of special operations appears on the screen, including the Load operation with an L in front of it. Pressing L produces a request for information identifying the file to be loaded (either the name of the file or the block numbers that contain the text). After entering the necessary information, the text file is loaded and

the beginning of the text appears on the screen. The cursor is still in the upper-left corner.

Suppose a word used midway through the text needs to be changed. Press the PAGE ↓ (page forward) key and hold it down. After pressing the key, the next page (full screen) of text replaces the first. A second later, the screen is repeatedly replaced with new pages of text at a rate of 10 pages per second until the key is released. Looking at the text presently filling the screen, you see that you have not reached the text area desired. A few taps of the PAGE ↓ key bring the desired text into view.

To move the cursor to the line with the word, press the ↓ (cursor down) key and hold it down. The cursor first moves to the beginning of the second line and then, after a one-second pause, quickly moves down the screen (always in the left column). Releasing the key at the right moment stops the cursor on the desired line.

Pressing the → (cursor right) key moves the cursor to the right (using the same automatic repeat feature) until it is almost to the word. A couple of extra taps of the same key and the cursor is to the immediate left of the word to be corrected, ready to make the change.

The process of replacing the incorrect word with the correct one requires use of the ERASE CHAR (erase character) key to erase the present word (again making use of the automatic repeat feature). Then, typing the desired word inserts it into the text at the proper location. As these changes occur, the portion of the line to the right of the cursor shifts left as the incorrect characters are erased, and it shifts right to make room for the inserted characters. Watching these changes take place is fascinating.

Although the explanation of finding and correcting the word in this example is lengthy, the time required to do it is only about 15 seconds. And, since the use of the operations is natural, editing requires less concentration than when using a traditional text editor, leaving you free to think about the text itself.

To move to the end of the text, press the ESC key to enter the menu mode again and then press B (for Bottom). The screen is now filled with the last full screen of text and the cursor is at the end of the last line.

There is nothing special about adding characters to the end of the text; it is done simply by typing characters into the text at the end. At the end of a line, the carriage-return key is pressed to indicate the end of that line and the beginning of a new line.

When a character is incorrectly typed, the ← (cursor left) key is pressed once and normal typing is continued. Later, usually at the end of the line, the ERASE CHAR key with the automatic repeat feature, or the ERASE LINE key, is used to erase incorrect characters that have accumulated to the right of the cursor. This approach was chosen to reduce the number of keys needed. But if another key is available, a RUBOUT key (which erases the character just typed in) can easily be included. (However, I have seldom regretted the lack of a RUBOUT key.)

After the text has been modified, to save the updated version on floppy disk or tape, press the ESC key and then S (for Save). The editor will request information that indicates where you want it saved (as in the Load operation). After you have entered the information and the text has been saved, the first page of the text appears on the screen and the editor is ready for more editing.

The Screen Format

Although the entire screen is available for displaying the text, only a portion of the text can appear on the screen at one time (unless the text is very short). Since the cursor must always be visible, only the text near the cursor can appear on the screen.

If the cursor is moved to a position not presently within view, scrolling takes place. *Vertical scrolling* changes the screen by shifting the lines up or down. In doing so, a new line appears at the top or the bottom of the screen and a line disappears at the opposite end.

Since lines can be longer than the display device can fit on a single line, *horizontal scrolling* allows the ends of

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Operation	Key(s) Used	Description of Operation	Special Cases in Which No Change Occurs
CURSOR UP	↑	If the cursor is already at the beginning of a line, the cursor is moved to the beginning of the previous line. Otherwise, it is moved to the beginning of the same line.	The cursor is already at the beginning of the text.
CURSOR DOWN	↓	The cursor is moved to the beginning of the next line.	The cursor is already at the end of the text.
CURSOR LEFT	←	The cursor is moved left by one character. If the cursor is at the beginning of a line, the cursor is moved to the end of the previous line.	The cursor is already at the beginning of the text, or there is no more room in memory (in which to expand compressed-space-bytes).
CURSOR RIGHT	→	The cursor is moved right by one character. If the cursor is at the end of a line, the cursor is moved to the beginning of the next line.	The cursor is already at the end of the text, or there is no more room in memory (in which to expand compressed-space-bytes).
PAGE FORWARD	PAGE ↓	A new full screen of text immediately below the presently visible text is displayed. The cursor is moved to the upper-left corner of the screen. If the end of the text is already on the screen, the cursor is moved to the end of the text.	The cursor is already at the end of the text.
PAGE BACKWARD	PAGE ↑	A new full screen of text immediately above the presently visible text is displayed. The cursor is moved to the upper-left corner of the screen.	The cursor is already at the beginning of the text.
TOP	ESC , T	The cursor is moved to the top (beginning) of the text.	The cursor is already at the beginning of the text.
BOTTOM	ESC, B	The cursor is moved to the bottom (end) of the text.	The cursor is already at the end of the text.
INSERT CHARACTER	Any character key	The appropriate character (indicated by the key that was pressed) is inserted into the text to the immediate left of the cursor.	There is no more room in memory.
INSERT CARRIAGE RETURN	CR	A carriage return is inserted to the immediate left of the cursor. (This creates a new line or divides an existing line into two lines.)	There is no more room in memory.
ERASE CHARACTER	ERASE CHAR	The character or carriage return to the right of the cursor is erased.	There is no text to the right of the cursor.
ERASE LINE	ERASE LINE	If the cursor is at the beginning of a line, the entire line is erased (including the carriage return at the end). Otherwise, the portion of the line to the right of the cursor is erased (without erasing the carriage return at the end).	There is no text to the right of the cursor or the cursor is at the end of a nonempty line.
ERASE ALL	ESC, !	The entire text is erased.	There is no text in the editor.
PRINT	ESC, P	The entire text is sent to the printer. (No changes are made in the text.)	There is no text in the editor.
LOAD	ESC , L	Text from the mass-storage device is inserted into the text to the immediate right of the cursor. (This operation is used both for combining text files and for initially loading a text file into the editor.)	There is not enough room available in memory.
SAVE	ESC , S	A copy of the entire text is saved on the mass-storage device. (The text remains in the editor.)	There is no text in the editor.

Table 1: *Editing operations for the VDO text editor. Except for the SHIFT operation, they can be classified in four basic categories: cursor-movement operations, insertion operations, erasure operations, and operations that transfer text to and from the peripheral devices (mass storage and printer). The operations that do not involve the use of the ESC key can be repeated quickly using the automatic repeat feature. Additional comments concerning the use of these operations are given in the text.*

START HERE	ESC , H	This operation defines the beginning of the portion of text to be used in the COPY or ERASE PART operations.	(Always has an effect.)
COPY	ESC , C	A copy of the portion of the text between the "START HERE" location and the present cursor location is saved on the mass-storage device. (The text is not changed.)	There is no text in the editor, or the cursor has been moved ahead of the "START HERE" location.
ERASE PART	ESC, *	The portion of the text between the "START HERE" location and the present cursor location is erased.	There is no text in the editor, or the cursor has been moved ahead of the "START HERE" location.
SHIFT	CTRL-A	If the character to the right of the cursor is an alphabetic (A-Z) character, it is shifted between UPPERCASE and lowercase (whichever is opposite). Also, regardless of whether the character was shifted, the cursor is moved right one character (equivalent to the CURSOR RIGHT operation).	There is no text to the right of the cursor.

long lines to be viewed whenever desired. Horizontal scrolling is analogous to vertical scrolling, except that the text (all of it) is shifted left or right. This approach was taken rather than using wraparound (in which a second line is used for displaying the extra characters) because the appearance of the text can be confusing with that approach and because the effect of the CURSOR UP and CURSOR DOWN operations would be erratic.

Explanation of Editing Operations

A full list of the operations implemented in this text editor is given in table 1. The operations were designed to be simple but powerful. With the exception of the shift operation, they are classified in four general categories:

- cursor-movement operations
- insertion operations
- erasure operations
- operations that transfer text between the peripheral devices and the editor

The information presented in table 1 clearly defines what these operations do, but explanations of how they are used are given below. (Since the information in the table is not repeated here, the table should be referenced while reading this section.)

To make the movement of the cursor easy, eight cursor-movement operations are available. They move the cursor forward and backward by character (CURSOR RIGHT and CURSOR LEFT), by line (CURSOR DOWN and CURSOR UP), by page (PAGE FORWARD and PAGE BACKWARD), and to the ends of the text (BOTTOM and TOP). In conjunction with the automatic repeat feature, they allow the cursor to be moved easily both short and long distances.

The only cursor-movement operations that have not yet been fully explained are the PAGE FORWARD

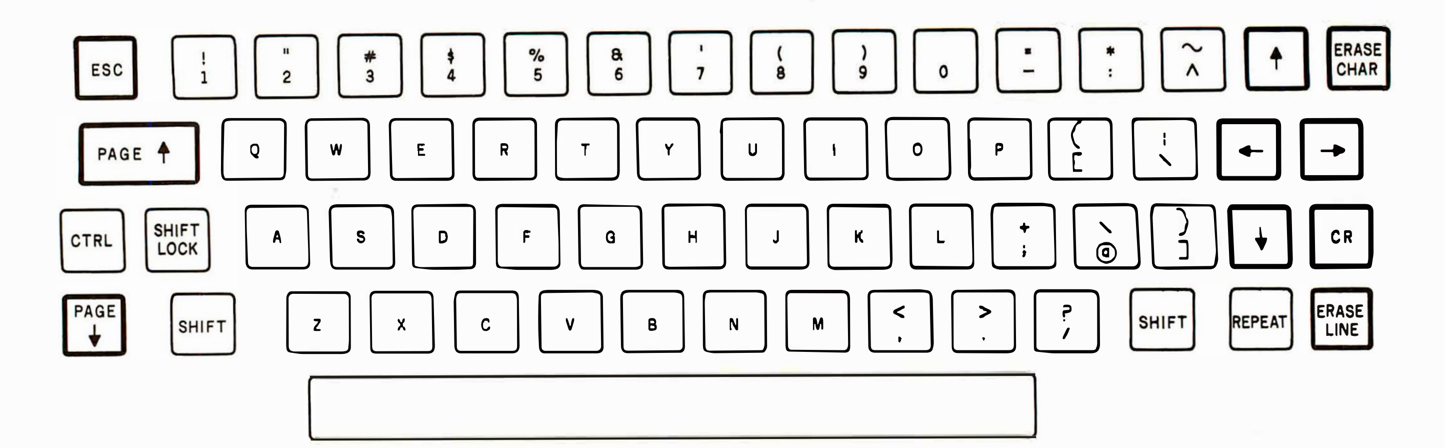


Figure 1: *The keyboard layout on the author's system. The important noncharacter keys are outlined in boldface. Note the natural orientation of the four clustered cursor-movement keys (with the arrows). Pressing any character key causes that character to be inserted into the text. Except for the SHIFT operation (accessed by the SHIFT-A combination), the remaining editing operations are accessed by pressing the ESC (escape) key to enter the menu mode.*

The author's keyboard is not standard with respect to the SHIFT and CTRL keys. Also, the REPEAT key is not used. The special editing keys shown here replace unneeded keys marked BREAK, LINE FEED, TAB, BACKSPACE, HERE IS, CLEAR, DELETE, and two unassigned keys.

and PAGE BACKWARD operations. Their effect is to display the full screen of text immediately following or preceding the text presently visible—analogous to flipping the pages of a book. The cursor is moved to the upper-left corner of the screen in either case, regardless of where it was before. These operations are very useful for moving through the text quickly or for finding a specific area of the text.

The insertion operations—INSERT CHARACTER and INSERT CARRIAGE RETURN—allow letters, numbers, symbols, spaces, and carriage returns to be inserted into the text wherever desired. Pressing any character key or the carriage-return key causes the character or a carriage return to be inserted into the text to the immediate left of the cursor. This allows characters to be entered from left to right, the normal direction for typing.

Although the insertion of a carriage return is done the same as any other character, the effect is worth commenting on. If a carriage return is inserted into the middle of a line, it separates the line into two separate lines; but if a carriage return is inserted at the beginning or the end of a line, a new empty line is created wherever the cursor is, and the line can then be filled if desired.

The erasure operations—ERASE CHARACTER, ERASE LINE, and ERASE ALL—allow characters, lines, or the entire text to be erased. A fourth erasure operation, ERASE PART, is also available, but because it is often used in conjunction with one of the text-transfer operations, it will be discussed later.

The ERASE CHARACTER operation is straightforward. Whatever character is to the immediate right of the cursor is erased by this operation.



In conjunction with the automatic repeat feature, it allows any short portion of the text to be easily erased. If the character to the right of the cursor is a carriage return (i.e., if the cursor is at the end of a line), this operation erases the carriage return, causing two lines to be combined into one longer line.

The effect of the ERASE LINE operation is that the remainder of the line containing the cursor, starting at the location of the cursor, is erased. However, the carriage return at the end of the line is erased only if the cursor is at the beginning of the line. This distinction provides two modes of operation that are both useful: in cases where all the characters on the line are to be erased, it is usually desirable to also erase the carriage return at the end. But in cases where the beginning part of the line is to remain intact, the carriage return is retained to avoid combining that line with the next line.

The final erasure operation, ERASE ALL, is self-explanatory in its effect, but there might be some question as to why it is needed. Unlike some editors, this editor does not have to be exited and reentered in order to finish editing one file and start editing a different file. Instead, the updated first file is saved, the ERASE ALL operation is used to eliminate that file from memory, and the second file is then loaded into the editor. This approach allows greater flexibility in manipulating the files on mass storage.

It should be noted that the text files referred to above must be short enough to fit into the main memory entirely. Although this type of text editor could be programmed to handle very large files (provided a disk drive is used as the mass-storage device), the additional programming effort needed to implement it would be substantial.

This editor accommodates two types of peripheral devices: a printer and some form of mass storage. Any of the usual mass-storage devices—audio-cassette tape recorders, digital-cassette tape drives, floppy-disk drives, or hard-disk drives—can be used for storing the text files.

The only operation that pertains to the printer is the PRINT operation. It sends the entire text to the printer to be printed. (This print operation does not have text-formatting capabilities—sometimes included in a text editor to form a word-processor program.)

Three operations can transfer text between the mass-storage device and the editor: the LOAD, SAVE, and COPY operations. The LOAD operation gets a file of text from the mass-storage device and inserts it into the text at the location pointed to by the cursor. This operation is used both for initially loading text into the editor when it is empty and for combining previously created text files. The SAVE operation stores the entire text file on the mass-storage device. It is used not only to save the final version of a text file, but also to store backup or intermediate versions of the text. Finally, the COPY operation saves just a portion of the text on the mass-storage device. It is usually used for making a copy of a portion of text needed elsewhere (either in the same file or another).

Since the COPY operation cannot be used by itself to indicate which part of the text is to be copied, the START HERE operation is used to indicate where the section to be copied begins. The COPY operation is then used to indicate the end of the section to be copied and it initiates the transfer operation. However, if the cursor is moved above the "START HERE" location before the COPY operation is used, the COPY operation will produce an error message (due to the potential for accidentally changing the starting point).

The COPY operation is also useful for moving (as opposed to just copying) portions of text to different positions in the file. To allow this to be done easily, the ERASE PART operation is included. When it is used immediately after the COPY operation, it erases the portion of text just copied. The copied portion of text can then be inserted elsewhere by using the LOAD operation.

If you are familiar with editors that incorporate special buffers for saving text, it may have occurred to you that



this scheme for storing and retrieving sections of the text on mass storage allows the same types of manipulations to be done, but without the complicated special commands needed to manipulate those special buffers. This ability to transfer text to and from mass-storage files allows virtually any manipulations of text to be done with a few simple operations.

As mentioned earlier, the use of the ERASE PART operation is not restricted to its use with the COPY operation, although it is most commonly needed there. In conjunction with the START HERE operation, it allows large portions of the text to be erased easily.

The explanation of the SHIFT operation has been left for last because it does not fit into any of the four basic categories. It transforms letters from uppercase to lowercase or vice versa, but it affects only letters (not numbers, symbols, etc.), and it moves the cursor right by one character. When alternately used with the CURSOR RIGHT key, it allows text to be easily changed to lowercase where needed, having been entered in uppercase only. I implemented this operation to allow the use of lowercase letters on my system (which has a keyboard that does not generate them); on most microcomputers, this operation is not needed.

That completes the explanation of the editing operations chosen for this editor. Although they are few and simple, they allow textual material to be manipulated easily according to normal needs. The only useful operations this editor lacks are the SEARCH and REPLACE operations. Although traditional editors would be impractical without them, they are optional on this editor. (They are particularly useful for changing the names of variables in a program or changing key words in a form letter. However, they are not needed in this editor for helping to move the cursor to a desired location or for manipulating characters within a line—their primary function in traditional editors.)

Keyboard Requirements

Although it would be nice if all the operations had their own keys, most keyboards do not have enough keys. The operations that should, if at all possible, have their own keys are the CARRIAGE RETURN, CURSOR UP, CURSOR DOWN, CURSOR LEFT, CURSOR RIGHT, ERASE CHARACTER, and ESC operations. If available, keys not otherwise used by the editor can be used for these operations. Otherwise, the SHIFT and CTRL (control) keys must be used in conjunction with particular character keys to control these and the remaining operations—although this significantly reduces the convenience of the editor. The other operations that must be accessed by unique codes (either by being assigned to their own keys or through the use of the SHIFT and CTRL keys) are the ERASE LINE, PAGE FORWARD, PAGE BACKWARD, and SHIFT operations. These operations require unique codes because they must be accessible via the automatic repeat feature. The key assignments for my keyboard are shown in figure 1.

Since the automatic repeat feature is implemented in software, there must be a software-testable connection to indicate when a key is being held down. The ASCII (American Standard Code for Information Interchange) code for the key being pressed must also be available to the computer, but it need not be supplied to the same input port as the key-pressed-status bit.

The subroutine to implement the automatic repeat feature pauses between repeated operations or waits for another key to be pressed after the key has been released. If this editor is implemented on a system without provisions for allowing the key-pressed-status to be checked, an extra connection must be added. Although other methods for implementing the automatic repeat feature are possible, they require significant changes to the program.

Video-Display Requirements

The most critical hardware requirement for implementing the VDO text editor is that the entire video-display screen must be capable of being rewritten within about a tenth of a

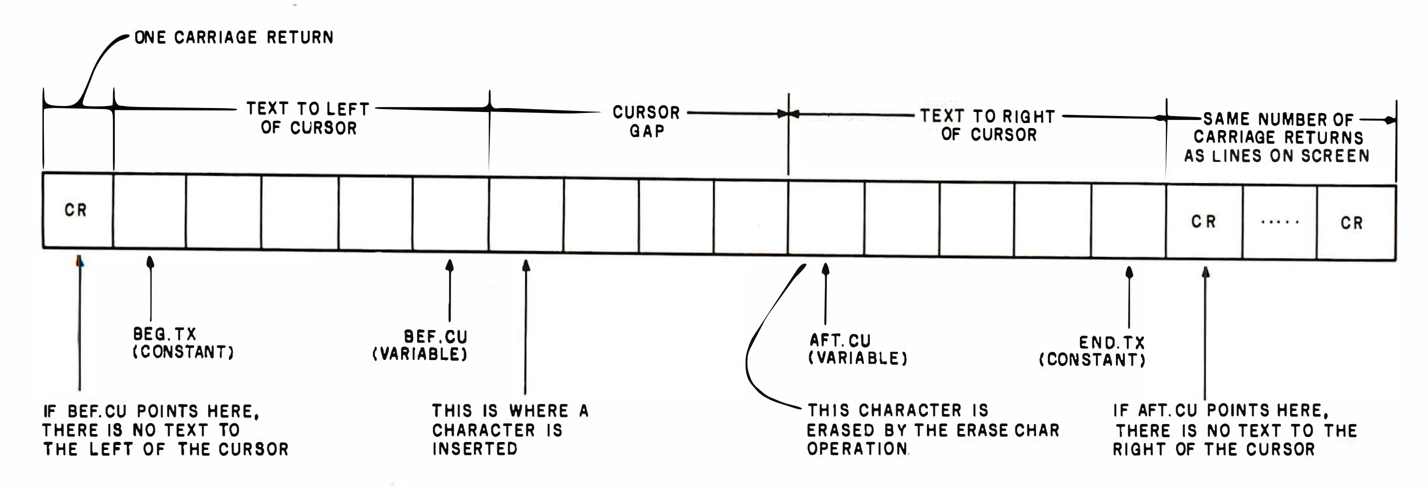


Figure 2: *The structure of the text as stored in memory. Carriage returns are added to the ends of the text area to simplify the editor program, but they are not considered part of the text. The available text area extends from BEG.TX to END.TX, but the BEF.CU and AFT.CU pointers indicate how much of this area contains text; the unused portion constitutes the "cursor gap." The text code used for characters (except spaces) and carriage returns is ASCII, with the eighth bit set to 1. Spaces are represented when the eighth bit is set to 0, in which case the other 7 bits indicate the* number *of adjacent spaces stored at that location. In this diagram, memory-address numbers increase to the right.*

second, preferably even faster. Thus, any display device connected via a serial line is too slow. The only display devices fast enough are those connected in parallel and those that are memory-mapped. (The memory-mapped type stores the characters in a special section of memory. The display circuitry repeatedly accesses those memory locations as they are needed for the display.)

In order to find out how fast your video-display device can be updated, write an assembly-language program to fill the screen 1000 times (with any characters) and then erase the screen. Measure the time between the first update and the time at which the screen goes blank. Divide the measured time (in seconds) by 1000, and that is the time required for updating the screen once. For best results, the time for one update should be less than 0.05 seconds, since that leaves one-twentieth of a second for the computer to do the editing operation and determine which characters to display.

For purposes of comparison, my display device—a parallel-connected type with 16 lines of 64 characters—can be updated in 0.04 seconds. With the Z80 microprocessor running at 2.5 megahertz, the execution time for one update, including calculations, is about 0.08 seconds.

If your display device is not fast enough, the program will not be usable as written. However, a compromise form of text editor could be implemented by keeping only one line (or a few lines) of text visible, instead of a full page. The PAGE FORWARD and PAGE BACKWARD operations could then be used to display a full screen of text each time they are used. The results are not as impressive, but they are preferable to many traditional editors.

There are only two operations that the text-editor program requires of the video-display device: to display a character in the next position on the screen, and to reset the display so the next character to be displayed will appear in the upper-left corner of the screen. There is no need for a carriage-return operation because the program assumes that a new line is automatically started when the right side of the screen is reached. The two subroutines that handle the display device can be written to handle most

hardware configurations, but the presence of a visible "hardware cursor" may require some changes in the program itself.

Internal Representation of Text

The code used for storing the text includes the standard ASCII 7-bit code. The extra (eighth) bit of each byte is used to distinguish between ASCII (indicated by the most significant bit set to 1) and a special representation of multiple-adjacent spaces (most significant bit set to 0). These "compressed-space-bytes" allow a series of adjacent spaces to be combined into a single byte by using the 7 least significant bits as a binary number indicating the number of spaces represented (up to 127). This representation can significantly reduce the amount of memory required for storing textual material, especially when indentation is a dominant feature of the text—as in most computer programs. This special implementation of spaces complicates the editor program, but the saving in memory usage is worth it.

The editor recognizes ASCII carriage returns as end-of-line indicators, but it assumes that all other ASCII values are displayable characters. Therefore, control codes (such as Tab, Line Feed, and Backspace) are treated as characters if they get into the text. The one code that could cause the program to crash is the binary number 0 (which would otherwise represent 0 adjacent spaces). But as long as all the text is entered via this editor, problems do not arise since checks are made to avoid such insertions.

The text is stored in a single continuous block of memory located anywhere in programmable memory. Pointers are used to divide the area into three parts: the text to the left of the cursor, the text to the right of the cursor, and the cursor gap. (See figure 2 during this and the following explanations.) The two halves of the text, corresponding to the text to the left and right of the cursor, are stored near the ends of the available memory area, with the beginning of the text at the lower end and the end of the text at the higher end. The section of memory between the two halves of text is called the cursor gap and its contents are unimportant. The advantage of keeping the unused portion of memory at the cursor location is that insertions and erasures do not require the shifting of numerous characters, allowing the editing operations to be done quickly.

Four variables are used to point to the boundaries of these three areas: BEG.TX (begin text), BEF.CU (before cursor), AFT.CU (after cursor), and END.TX (end text). The locations they point to are best understood by referring to figure 2. As the figure indicates, the BEG.TX and END.TX pointers point to the first and last bytes of text, respectively, and the BEF.CU and AFT.CU pointers point to the bytes to the left and right of the cursor, respectively. The BEG.TX and END.TX pointers always point to the same memory locations despite changes in the text. But either or both of the BEF.CU and AFT.CU pointers change with almost every editing operation. As indicated in the figure, special considerations apply when the cursor is at either end of the text, or if

there is no text at all. (When there is no text to the left of the cursor, BEF.CU = BEG.TX − 1; when there is no text to the right of the cursor, AFT.CU = END.TX + 1.)

There are three basic ways in which the text can be modified:

- moving the cursor
- erasing text
- inserting text

These changes are made as follows: Cursor-movement operations are achieved by moving one or more of the bytes adjacent to the cursor gap to the opposite end of the cursor gap (keeping the bytes in the same order) and updating the BEF.CU and AFT.CU pointers to indicate the new structure. Erasure operations (for text to the right of the cursor) are achieved by increasing the value of the AFT.CU pointer. (Although no changes are made in the text area, some of the bytes of text are reclassified as being part of the cursor gap.) Finally, the insertion of text (to the left of the cursor) is done by storing new byte(s) at the lower-address end of the cursor gap and increasing the value of BEF.CU to point to the last byte of the inserted text. Although these three basic types of editing operations are simple in concept, complications arise because of the many special cases that can occur.

A final comment about the internal text format is that extra carriage returns are added to each end of the text area to reduce the number of special cases to be checked (see figure 2). However, these carriage returns are not considered part of the text being edited.

Program Implementation

The source listing of the VDO text editor will be presented next month in part 2 of this article. It is written in assembly language for either 8080 or Z80 microprocessor-based computers and occupies less than 2.2K bytes of memory. The comments provide the documentation necessary for implementing it, but implementation does require a familiarity with assembly-language programming and an understanding of the operation of your computer. Eight input/output subroutines, examples of which will be included next month, must be written to interface the program with either your input/output devices or your operating system. The comments also enable the program to be modified to fit specific needs or even to be translated into another machine's language. (In addition to the obvious reasons for including clear comments, I find that software is actually easier to write if clear comments are written at the same time the computer instructions are written.)

I am offering this program as a commented source listing to help other computer experimenters who cannot accommodate the commercially available editors of this type. However, the implementation of this program is not trivial, so if your system is compatible with a ready-to-use editor that offers the conveniences of this approach, you may be better off trying it instead. But whichever route you take, you can look forward to more enjoyable and productive editing sessions on your microcomputer. ■

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News and Speculation About Personal Computing

Conducted by Sol Libes

Random Rumors: Motorola's research-and-development group is rumored to be progressing nicely with a new 32-bit microprocessor design, and information on its specifications is being leaked. It will have a 4-gigabyte (4-billion-byte) direct-address range, a memory cache to increase throughput, and new instructions such as bit, field, and block moves; it will support ASCII (American Standard code for Information Interchange) and bit-field data types. The device itself will be composed of 120,000 transistors and will consume ⅔ watt of power. Motorola is expected to start providing samples of the device before the end of next year. . . . Micropro is reportedly working on a full-color version of its Wordstar word-processor software for the IBM Personal Computer; the new version may run under MS-DOS. . . . Epson is expected to officially start shipping its personal computer system to dealers this month. . . . Wang Laboratories, the well-known word-processor manufacturer, is said to be readying an entry into the personal computer market.

Sinclair Does It Again: Clive Sinclair, the Englishman who shook up the microcomputer industry with the ZX80 and ZX81, is doing it again, namely, undercutting his competition. In England Sinclair Research Ltd. has introduced a new machine called the ZX Spectrum with a selling price equivalent to about $194. The machine sets a new high in its performance/price ratio that will shake up competitors such as Radio Shack, Atari, Commodore, and TI (Texas Instruments). It offers color, high-resolution graphics, sound generation, and more. The machine is an addition to the Sinclair computer line, so the current ZX81 will remain in production (in fact, its production is being increased to 150,000 a month). Do not expect the ZX Spectrum to become available in the United States until year-end, and even then it will be available by mail order only.

The new machine, which is about the same size as its predecessors, offers a keyboard with real keys, 16K bytes of memory (for an additional $60 you can have a total of 48K bytes), and later this year Sinclair will introduce a 3-inch Microdrive (100K bytes storage per disk; 8 drives maximum) for less than $80 per drive. Also expect a $30 RS-232C interface for this machine; a small printer is already available.

The BASIC, which resides in ROM (read-only memory), is an extended version with full math, transcendental functions, and array-, string-, and graphics-handling capability. The keyboard and display offer both upper- and lowercase characters, and ASCII is used (there are 191 legends on 40 keys). The display format is 32 characters by 24 lines, with graphics resolution at 256 by 192 pixels, 8 colors, and features such as bright, flash, inverse, overprint, and user-defined characters.

With the upgrading of its machines to include larger memory, uppercase and lowercase, disk drives, and RS-232C, Sinclair is gradually shifting its focus from hobbyists to business users: people who use spreadsheets and other business software and are able to afford video terminals. When Sinclair introduces its flat-screen display, watch out!

IBM Doings: IBM has finally begun expanding its independent dealer organization; in June IBM appointed 16 independent computer-retailing operations, with a total of 62 outlets, as authorized IBM Personal Computer dealers. IBM is beginning to feel competitive pressure from suppliers of plug-compatible products. The result is that the company has dropped the price of its printer from $755 to $555 and that of its disk drive from $570 to $450.

IBM has also eliminated the ceiling on royalties from its contracts with independent software suppliers. The previous contract held a supplier's earnings to a maximum of $100,000, thus discouraging many software developers. Under the new terms, percentages, advances, and duration of payment will be individually determined based on the program distributed, its documentation, and relevant business and technical factors. There will be an initial simple contract signed when a program is submitted for evaluation by IBM, and a second contract will then be offered if and when the program is found acceptable for distribution by IBM.

Phase One Systems, Oakland, California, claims to have adapted its Oasis-16 multiuser operating system to run on the IBM Personal Computer and support up to three users. The firm claims that it is fully compatible with its Z80 version and that there are already over 400 business-application programs, written primarily in BASIC, available for it. The system allows private and shared files, with automatic record- and file-locking and optional password- and privilege-level protection. The system requires at least 128K bytes of memory and a 5-megabyte hard-disk system.

Telesoft, San Diego, has introduced an Ada compiler for the IBM Personal Computer. It provides a subset of Ada and utilizes the firm's proprietary ROS operating system.

IBM's Cambridge Scientific Center, Cambridge, Massachusetts, has disclosed that it is working on a research project to develop an easy-to-use, real-time editor-formatter, called Polite, similar to Xerox's Smalltalk operating system and language. It will also handle documents, images, data, graphics, and handwriting.

Apple Happenings: Apple Computer Inc. has filed suit against Franklin Computer Corporation of Pennsauken, New Jersey.

Apple alleges patent and copyright infringement by Franklin in designing its Ace-100 computer, introduced late last year. Specifically, Apple charges the company with copying Apple II programs on disk and in ROM.

Apple has also terminated its distributor in Japan and will set up its own marketing subsidiary in Tokyo. Apple reports that its sales volume in Japan doubled from fiscal year 1980 to fiscal year 1981.

Apple is rumored to be working on printers that use ink-jet and laser technologies at its accessory-products division in Garden Grove, California. Apple hopes to bring out printers using these technologies at prices substantially lower than those of other such printers. Apple is also believed to be working on a small flat-screen display at the same facility.

According to the police in Cupertino, California, several Apple employees allegedly helped direct the theft of $1 million worth of Apple III computers in less than a year. Five people have already been arrested. According to the police, the allegedly stolen computers retail for about $4500 and were sold for $900, mostly to businesses.

To Copy or Not to Copy: Suppliers of Apple software, in an attempt to protect their copyrighted programs, use a number of techniques to prevent copying. This has encouraged software suppliers to sell "copying" software. Notable examples are the Locksmith and Nibbles Away 2 programs. No software supplier has yet devised an unbreakable software coding system.

Locksmith and Nibbles Away 2 analyze the bit patterns and methods of encryption used on the disk to be copied and copy the bytes sequentially into the computer's memory and from there onto a new disk. It is claimed that over 15,000 copies of Locksmith have been sold since it was introduced in January 1981. It's worth noting that both Locksmith and Nibbles Away 2 use software protection against copying.

As yet no software supplier has taken the producers of Locksmith and other such programs to court. This is probably because the U.S. Copyright Act allows users to copy programs "for archival purposes only." And so far, unlike the record industry, no significant pirating for profit has developed.

Some software vendors require purchasers to sign a licensing agreement under which purchasers may be penalized if the vendor discovers an unauthorized copy of the software bearing the serial number of the purchaser's copy. Vendors have found that the combination of encryption and penalty clauses often has a negative effect on sales; hence some companies, including Apple Computer Inc., have given up on copyright protection.

Although copying by hobbyists has long been recognized as a problem, the copying that disturbs vendors the most is the copying done outside of the home. For example, a program vendor will find that a company or school may have tens or even hundreds of personal computers but buys only one copy of an application program and makes tens or hundreds of copies, one for use on each machine. Usually the purchaser has bought all these systems to run a specific application software program. But the software

company, who invested heavily in developing the program, feels that it receives a very small reward for its efforts while the hardware suppliers garner the real profits. Most software vendors specify that their software license is good only for use on a single machine and that additional licenses must be purchased for each machine the software is used on. However, few software purchasers abide by these terms.

Word Processing and Office Automation: Word-processing programs are being greatly improved in their abilities to create, edit, and print text. Even more important are the features being added that will allow users to efficiently manage the office of the future. These features include the ability to store, copy, and merge documents; integrate variable and preformatted text; and perform mathematics, graphics, mailing, filing, appointment scheduling, and security-sensitive work.

Improved editing functions include automatic hyphenation of words and operations that allow blocks of text to be copied, moved, deleted, printed, and written to a disk file. Several new word-processing programs allow linking and merging files to build boilerplate documents such as form letters. Printing enhancements include such features as optional automatic page headings and numbering, in Roman or Arabic numerals, in any location on the page or alternating between right- and left-hand corners for book-style formats. Some programs also allow the printing of partial, single, and multiple documents, often while editing another document. Another new feature is the placing of variable fields in documents and the filling of the fields automatically from a disk file or manually from the keyboard to personalize letters. Thus, the modern word-processor program may be told to recognize a zip code and automatically insert a phrase directed to people in that particular area.

More and more of the newer word-processor packages also include Visicalc-type functions, automatic index and table-of-contents generators, and spelling and syntax checkers and correctors. Features such as business graphics, phone index, appointment calendar, and card-file functions are being added. Some are also connected to a host network for electronic mail and accessing of document libraries with password protection. All of these features are leading the way from word processing to the office automation of the future.

DEC Unveils Personal Computer Systems: "Better late than never" seems to be the DEC (Digital Equipment Corporation) maxim. Following in the footsteps of IBM and Xerox, the company has finally brought out four personal computer systems (described in the June 1982 BYTE Editorial), ranging in base price from $3495 to $4995: the Rainbow 100, the DECmate II, and the Professional 325 and 350. All use the same basic cabinetry except the 350, which has a larger box to house an internal Winchester-technology hard-disk drive. The Rainbow 100 is basically a dual-processor 8088/Z80 system that will run CP/M, MS-DOS, and Pascal (the UCSD p-System). The DECmate II is a low-cost version of its PDP-8-based word-processor system. Its Professional models are 16-bit computers and use the P/OS operating system, derived from DEC's PDP-11 operating system. Options for the Professional systems will include Ethernet and DECnet support and plug-in CP/M cards.

The DEC systems will be sold through Computerland, Hamilton/Avnet, and DEC retail outlets. DEC currently has 25 outlets; it opened 27 outlets 3 years ago and then closed 2 of them after the first year. It is rumored that these DEC retail stores have yet to show a profit. Considering that Computerland stores already carry virtually every popular business-oriented personal computer system (e.g., IBM, Apple, Osborne, Fortune, etc.), and that DEC's personal systems do not offer anything new, DEC may have an uphill battle in entering the personal computer market.

Robotics News: In Japan, Mitsubishi has introduced a robotics arm that can be connected to a microcomputer by way of a Centronics-type parallel port (not all the lines are used). Move Master software is provided that runs under CP/M. The cost in Japan is the equivalent of $5000. The product is intended as a teaching aid and for sales promotion. There is no word on when it might be introduced in the United States. For information write: Mitsubishi, 2-3 Marunouchi 2-Chrome Chiyoda-Ku, Tokyo 100 Japan; or call: (218)2173.

Find A Date With Your Computer: The newest thing in computerized bulletin-board systems is the "Dial-A-Match" system. Several such systems are already in operation on personal computers connected to telephone lines and are operated as free public services (contributions are welcome). Although the software varies from system to system, the procedure is pretty much the same. Call the system via modem with your computer or a terminal. If it is your first time on the system you will be asked to complete a questionnaire. The system will then match you up with other callers and furnish you with information on the person or persons you are matched with. You can then exchange messages with anyone else on the system.

Foreign Exchange: My list of foreign computer bulletin-board systems is growing; here's an update: systems in England include Forum-80 Hull (04-828-59169), Forum-80 London (01-747-3191), and Forum-80 Milton (09-085-66660). You might also try CBBS London (01-399-2136), Mailbox Liverpool (05-122-09733), or ACC (09-084-4262). In Holland there's Forum-80 (01-313-512-533), and based in Sweden are ABC-80 Stockholm (010-468-190522), University Research (010-468-23660; guest password: "66,66"), Elfa (010-468-7300706), and Tree Tradet (010-468-190522).

Random News Bits: Look for an R2D2-like robot kit to be introduced in the January Heathkit catalog. The 2-foot 2-inch 6808-based Hero 1 will have simulated eyes, ears, and a voice (using the Votrax SC-01 chip) and will be highly mobile. The kit will cost approximately $1000; an optional $100 manipulator (arm) will be available, as will a $150 *robotics* course. . . .**M.H.**

Dataquest, a marketing research firm, reports that the Intel 8086 is still the leading 16-bit microprocessor, with an estimated 78% of the market, compared with 15% for the Motorola 68000 and 6.6% for the Zilog Z8000. Dataquest reports that last year 718,000 Intel 8086 processors were shipped, compared to 139,000 Motorola 68000s and 61,000 Zilog Z8000s. . . . Prices for single-board computers are dropping. Intel has dropped the price for its iSBC 88/25 (based on the Intel 8088) from $1295 to $790 (single unit) and $520 (large quantity) to meet competition from DEC's Falcon 16-bit unit. . . . Texas Instruments will distribute 430 programs of Control Data Corporation's Plato software for its TI-99/4A home computer in 108 courses for kindergarten through high school levels. . . . Telegenix Corp., Cherry Hill, New Jersey, has introduced a giant (measuring more than 10 feet diagonally) 80-character by 24-line neon planar-gas display panel and controller. Price is only $52,500. . . . Perex Inc., San Jose, California, has introduced the first S-100 Ethernet interface (a two-board set). . . . Zilog has introduced an 8-user Unix-like system, called the System 8000, with a base price of $13,000. . . . Vector Graphic Inc., Thousand Oaks, California, following in the footsteps of Apple, has terminated its supply contract with Computerland. Apparently sales slumped dramatically when Computerland took on the IBM Personal Computer, DEC, et al. Computerland, before these defections, carried 20 different computer lines. Vector Graphic stated that last year only 9% of its sales came through Computerland. . . . Evotek Corp., Fremont, California, has announced a 5¼-inch Winchester-technology hard-disk drive with up to 50 megabytes of storage. . . . HP (Hewlett-Packard) has signed a $30-million contract for Sony's new 3½-inch "microfloppy," which has an unformatted storage capacity of 440K bytes. HP is the first company besides Sony to adopt the drive. . . . Hitachi Ltd., Tokyo, has unveiled an 8088-based system that it claims is compatible with the IBM Personal Computer.

MAIL: I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed, stamped envelope.

Sol Libes
POB 1192
Mountainside, NJ 07092

Software Received

Apple

Adventure, an implementation of the original adventure game. For the Apple II; floppy disk, $10. Frontier Computing Inc., 666 North Main, POB 402, Logan, UT 84321.

Automaniac System, requiring an onboard clock card, this system can run a program or series of programs without supervision at a predetermined date and time. For the Apple II; floppy disk, $100. Geegery Software Works, POB 8028, Des Moines, IA 50301.

Chess Connection, a telecomputing chess game that requires two computers equipped with modems for an interactive game. For the Apple II; floppy disk, $35. Telephone Software Connection Inc., POB 6548, Torrance, CA 90504.

Choplifter, an arcade-type game. You control a helicopter in an effort to rescue hostages held captive in a foreign country. For the Apple II; floppy disk, $34.95. Broderbund Software, Entertainment Software Division, 1938 Fourth St., San Rafael, CA 94901.

Escape from Rungistan, an adventure-type game. You must contend with cannibals, snakes, guerilla warriors, and a mad dictator's revenge while trying to escape from this interesting jungle nation. For the Apple II; floppy disk, $29.95. Sirius Software Inc., 10364 Rockingham Dr., Sacramento, CA 95827.

Fly Wars, an arcade-type game. You maneuver a spider to trap the flies. For the Apple II; floppy disk, $29.95. Sirius Software Inc. (see address above).

Go-Moku, a telecomputing version of the oriental board game go-moku. This program requires two computers equipped with modems for an interactive game. For the Apple II; floppy disk, $20. Telephone Software Connection Inc. (see address above).

Graphics Processing System: Professional Version, a graphics development system that lets you create, manipulate, and edit images. Includes zoom, two-dimensional rotation, and overlay functions. For the Apple II Plus; floppy disk, $99.95. Stoneware Inc., 50 Belvedere St., San Rafael, CA 94901.

Horse Racing Classic, a highly detailed simulation of horse racing for one to nine players. You can check a horse's statistics, place bets, and watch the race. For the Apple II; floppy disk, $36.95. Tasumi Software International Inc., 8 North Grosvenor Ave., Burnaby, British Columbia, V5B 1J2 Canada.

Millionaire, a stock-market game that lets you simulate investing in the stock market. You can examine company histories and buy stocks using a variety of options. For the Apple II; floppy disk, $49.95. Micro-Z Applications, Suite 141, 22704 Ventura Blvd., Woodland Hills, CA 91364.

Real Estate Models for the Eighties, Visicalc templates for real-estate analysis. Using the Visicalc program, you can calculate figures for a wide variety of mortgages and amortization plans. For the Apple II and III; floppy disk, $65. Commercial Software Systems, 7689 West Frost Dr., Littleton, CO 80123.

Speed Reader, a series of programs to help increase your reading speed. For the Apple II; floppy disk, $70. Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014

The Snapper, an arcade-type game. You must travel around the grid collecting blots but avoiding the Gamma Field and Whirlers. For the Apple II; floppy disk, $32.95. Silicon Valley Systems, Suite 4, 1625 El Camino Real, Belmont, CA 94002.

Statistics with Daisy, a data-analysis and interactive-statistics package. You can sort, analyze, and plot data using simple, easy-to-learn commands. For the Apple II; floppy disk, $79.95. Rainbow Computing Inc., 19517 Business Center Dr., Northridge, CA 91324.

Super-Text, a word-processing program that works with both 40- and 80-column screens. Instructions to make the shift key operational when used with a lowercase adapter are included. For the Apple II; floppy disk, $175. Muse Software, 347 North Charles St., Baltimore, MD 21201.

System/ASM 3A, an assembly-language development system that features a two-pass assembler, full-screen editor, and disk-file management. For the Apple II Plus; floppy disk, $35. Mike Piaser Co., 15401 Maple Park Dr. #11, Maple Heights, OH 44137.

Tele-Gammon, a telecomputing backgammon game. The program requires two computers equipped with modems for an interactive game. For the Apple II; floppy disk, $35. Telephone Software Connection Inc. (see address above).

Understand Yourself, a series of nine tests to help you understand your feelings about marriage, sexual attitudes, and other aspects of your life. For the Apple II Plus; floppy disk, $24.99. Huntington Computers, 1945 South Dairy Ave., POB 787, Corcoran, CA 93212.

Wizardry: Knight of Diamonds, the second scenario in the Wizardry game series. For the Apple II; floppy disk, $34.95. Sir-tech Software Inc., 6 Main St., Ogdensburg, NY 13669.

Wizardry: Proving Ground of the Mad Overload, a multiplayer fantasy and adventure game. You can develop your own characters in a Dungeon and Dragons-type game setting. For the Apple II; floppy disk, $49.95. Sir-tech Software Inc. (see address above).

Atari

Alvin, an arcade-type game. A reverse on the Missile Command format; you control the missiles trying to destroy a robot city. For the Atari 400 and 800; floppy disk or cassette, $21.95 and $17.95, respectively. Dynacomp Inc., 1427 Monroe Ave., Rochester, NY 14618.

Frog Master, a graphics program illustrating the use of operant conditioning. Through positive reinforcement, you train your frog to penetrate barriers and score goals for you. For the Atari 400 and 800; floppy disk or cassette, $21.95 and $17.95, respectively. Dynacomp Inc. (see address above).

Golf Pro, a simulation of a golf game using color and graphics. For the Atari 400 and 800; floppy disk or cassette, $21.95 and $17.95, respectively. Dynacomp Inc. (see address above).

NYIndex, a program that can store and plot up to three years of New York Stock Exchange information, from which you can determine the trend of the market based on past behavior. For the Atari 400 and 800; floppy disk, $29.95. Dynacomp Inc. (see address above).

Quintominoes, a screen-based jigsaw game. For the Atari 400 or 800; floppy disk or cassette, $16.95 and

$12.95, respectively. Dynacomp Inc. (see address above).

Heath

Space Odyssey I, an arcade-type game. Retrieve your deep-space probes as you maneuver around or destroy asteroids, alien fighters, and mysterious objects. For the Heath H-8 and H-19 or H-89; floppy disk, $21.50. Evryware, POB 60802, Sunnyvale, CA 94088.

Y-Wing Fighter, an arcade-type game. Pilot your fighter in a crucial mission to destroy the enemy's base. For the H-8 and H-19 or H-89; floppy disk, $19.50. Evryware (see address above).

IBM Personal Computer

Millionaire (see description above). For the IBM Personal Computer; floppy disk, $49.95. Micro-Z Applications, Suite 141, 22704 Ventura Blvd., Woodland Hills, CA 91364.

Real Estate Models for the Eighties (see description above). For the IBM Personal Computer; floppy disk, $65. Commercial Software Systems, 7689 West Frost Dr., Littleton, CO 80123.

Speed Reader, programs to help increase reading speed. For the IBM Personal Computer; floppy disk, $74.95. Davidson and Associates, 6069 Groveoak Place #14, Rancho Palos Verdes, CA 90274.

TRS-80

ABE: Advanced BASIC Edtior, a BASIC programming editor that lets you list programs a page at a time, use global search and replace to modify a program, and write commands with a single key press. For the TRS-80 Model I; floppy disk, $19.95. Interpro Corp., POB 4211, Manchester, NH 03108.

Bounceoids, an arcade-type game. Try to clear the Bounceoid boulders from the screen while avoiding the Bounceoid creatures. For the TRS-80 Models I and III; floppy disk or cassette, $19.95 and $15.95, respectively. The Cornsoft Group, 6008 North Keystone Ave., Indianapolis, IN 46220.

Co-Dir, a cursor-oriented directory. Select programs from a directory by positioning the cursor next to the filename. For the TRS-80 Models I and III; floppy disk, $19.95. Picotrin Technology, 3531 San Castle Blvd., Lantana, FL 33462.

Copy-Tape, a cassette tape-duplication program. For the TRS-80 Models I and III; cassette, $11.95. Modtec, 4144 North Via Villas, Tucson, AZ 85719.

IDM-X, a database-management system. Features include a built-in sort and merge package and a fast key-access method for quick record access. For the TRS-80 Model II; 8-inch floppy disk, $399. Micro Architect Inc., 96 Dothan St., Arlington, MA 02174.

Interpro Flexible Mailing List, a mailing-list program. You can custom program a mailing list to your exact specifications. Up to 1000 names per disk are possible. For the TRS-80 Models I and III; floppy disk, $127. Interpro Corp. (see address above).

Maxi CRAS: Check Register Accounting System, a check writing and recording system. Using its menu-driven format, CRAS lets you set up income- and expense-account reports showing activity of one or more accounts over a period of time. For the TRS-80 Models I and III; floppy disk, $99.95. Adventure International, 507 East St., POB 3435, Longwood, FL 32750.

Personal File Manager, a database-management program. Designed for everyday use, this program features format-free file structures that accept almost any type of data. For the TRS-80 Color Computer; floppy disk, $17.95. Home Information Systems, 4006 Ellicott St., Alexandria, VA 22304.

Pocket Computer Primer, companion software to the book of the same name. Includes a variety of programs for home and office use. For the TRS-80 Pocket Computer; cassette, $8.95. Micro Text Publications Inc., Suite 27C, One Lincoln Plaza, New York, NY 10023.

Pocket Magic, companion software to the book of the same name. Includes a variety of simulations and games. For the TRS-80 Pocket Computer; cassette, $8.95. Micro Text Publications Inc. (see address above).

Records, a student grades record-keeping system. This system can handle as many as 200 students and it provides class rosters, evaluation scores, and final grades. For the TRS-80 Model III; floppy disk, $69.95. Microsoftware Services, POB 776, Harrisonburg, VA 22801.

Science and Engineering Sourcebook, companion software to the book of the same name. Includes a variety of programs for professional use. For the TRS-80 Pocket Computer; cassette, $8.95. Micro Text Publications Inc. (see address above).

Spector of Kzirgla, a graphics adventure game. Wind your way through the 13 floors of the maze as you slay monsters, collect treasures, fly a magic carpet, and even commit hari-kari if necessary. For the TRS-80 Color Computer; floppy disk or cassette, $21.95. Rainbow Connection Software, 3514 6th Place NW, Rochester, MN 55901.

Software Received

Other Computers

Checkbook, Income Tax, and **Budget Organizer**, personal financial-management programs. For the ZX81; cassette, $15. ZX-Panding Ltd., POB 25, Newton, NC 28658.

Flexfile, a database-management system that maintains a random-access database, including lists for mailing labels and accounting reports. For the PET/CBM; floppy disk, $60. Total Control Software, 1038 Pine St., Philadelphia, PA 19107.

FORTH for Interact, a version of the FORTH language based on the FORTH Interest Group Model. For the Interact computer; cassette, $12. Russell L. Schnapp, 8062 Gold Coast Dr., San Diego, CA 92126.

Improved Fixed Point Package, a replacement for Ithaca Intersystems fixed-point package. For the Ithaca Intersystems Pascal/Z; 8-inch floppy disk, $50. Brom Microsystems Engineering Inc., POB 616, Winona, MN 55987.

Lattice 8086/8088 C Compiler, a compiler for the C language running under MS-DOS. For S-100-based systems; 8-inch floppy disk, $500. Lifeboat Associates, 1651 Third Ave., New York, NY 10028.

Logical Analysis, a program to reduce any binary state, multivariable equation to its minimum form. Written in BASIC; source code, $5. Scientific Techniques, POB 8453, Greensboro, NC 27410.

MAC-00 and **MAC-05**, cross-assemblers for 6809-based systems. For SwTP (Southwest Technical Products) systems; 8-inch floppy disk, $150 each. Rushmore Micro Systems, 622 East Tallent, Rapid City, SD 57701.

Real Estate Models for the Eighties (see description above). For the Hewlett-Packard HP-87 and HP-125; floppy disk, $65. Commercial Software Systems, 7689 West Frost Dr., Littleton, CO 80123.

The Word Plus, an enhanced self-correcting spelling checker program. For CP/M-based systems; 8-inch floppy disk, $150. Oasis Systems, 2765 Reynard Way, San Diego, CA 92103.

WP6502 Word Processing, a word-processing program. For the M/A-Com (Ohio Scientific) OS65D; 8-inch floppy disk, $250. Dwo Quong Fok Lok Sow, 548 Broadway, New York, NY 10012.

WP6502 Word Processing (see description above). For the M/A-Com (Ohio Scientific) OS65U, 8-inch floppy disk, $300. Dwo Quong Fok Lok Sow (see address above).■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Clubs and Newsletters

USUS(UK) Conference Report

Dr. J. Hoppe of ETH (Eidgenossische Technische Hochschule) in Zurich, Switzerland, was the guest speaker at a recent conference of the USUS(UK) (UCSD p-System Users Society). The conference included details on data-capture systems under UCSD and panel sessions on networking and educational software. Tony Addyman, committee chairperson of the ISO (International Standards Organization), spoke on ISO Standard Pascal. USUS(UK) membership details are available from Mark Woodman, Mathematics Faculty, The Open University, Walton Hall, Milton Keynes, MK76AA, United Kingdom; Tel: (0908) 74066.

IBM PC Software Interchange

The IBM PC Software Interchange is a service that provides a means to obtain software inexpensively. Members can obtain most programs for $5, plus handling. Program topics include mailing systems, electronic file sort, games, and finances. Each withdrawal requires an original program contribution. Membership fees are $50 per year. For an informational packet, send $3 to Miracle Computing, IBM PC Software Interchange, Dept. 10, 313 Clayton Court, Lawrence, KS 66044.

PETs Strictly Allowed

Strictly Commodore is a monthly newsletter for Commodore PET, VIC-20, CBM, and SuperPET aficionados. It features articles with programming hints and tips, evaluations of hardware and software, recreational and educational programs, news of happenings in the Commodore industry, information requested by readers, and a software exchange for owner-developed software. Subscription rates are $18 per year. A sample issue is available for $2. For more details, write *Strictly Commodore*, 47 Coachwood Place NW, Calgary, Alberta, T3H 1E1, Canada.

Educational Software Evaluated

OECUP (Oklahoma Educational Computer Users Program) conducts evaluations of educational software by and for its members. Send a self-addressed, stamped envelope for application and further information to Richard V. Andree, OECUP, 601 Elm, Room 423, University of Oklahoma, Norman, OK 73019.

Organization for Computer Consultants

The New York/New Jersey Chapter of the ICCA (Independent Computer Consultants Association) has more than 240 individuals on its mailing list. The ICCA is a nonprofit organization dedicated to promoting professionalism within the data-processing industry and supporting the independent computer consultant. ICCA has participated in the White House Conference on Small Businesses, and it serves the business community by providing a free referral service. Many ICCA members are qualified professionals on data-processing subjects, and all abide by the ICCA Code of Ethics, which guarantees clients competence, integrity, objectivity, and confidentiality. The New York/New Jersey chapter is presently compiling an up-to-the-minute directory of its members. Further details are available from ICCA, POB 603, Middletown, NJ 07748, or call Harry A. Cozzi at (212) 430-6403 or (201) 862-4734.

Osborne Group Blossoms in Ohio

The Central Ohio Osborne Users Group is a rapidly growing club in the Columbus area. Meetings are held at 7:30 p.m. on the second Monday of each month at the Ohio Institute of Technology, Alum Creek Dr., Columbus. The group is eager to learn everything possible about the Osborne 1. A newsletter is being planned. Contact Newton Brokaw, Central Ohio Osborne Users Group, 2695 Donna Dr., Columbus, OH 43220, (614) 457-5716.

Trilingual DAI Computer News

Each month the DAInamic Personal Computer Users Club produces a 64-page trilingual magazine called *DAInamic*. Written in Flemish, French, and English, it contains programs, letters to the editor, reviews of articles in other journals, graphics, tips, and information of interest to the DAI personal-computer user. For details, contact *DAInamic*, Bruno Van Rompaey, Bovenbosstraat 4, 3044 Haasrode, Belguim. ■

Books Received

Advanced Baudot Radio Teletype for the TRS-80 Model I and Model III Microcomputer, volume 5, Robert M. Richardson. Chautauqua, NY: Richcraft Engineering Ltd. (1 Wahneda Industrial Park), 1982; 206 pages, 21 by 27 cm, softcover, ISBN 0-940972-06-9, $20.

Application Development Without Programmers, James Martin. Englewood Cliffs, NJ: Prentice-Hall, 1982; 350 pages, 18 by 24.5 cm, hardcover, ISBN 0-13-038943-9, $32.50.

BASIC Faster and Better & Other Mysteries, Lewis Rosenfelder. Upland, CA: IJG Computer Services, 1981; 288 pages, 21 by 27.5 cm, softcover, ISBN 0-936200-03-0, $29.95.

CAI Sourcebook, Robert L. Burke. Englewood Cliffs, NJ: Prentice-Hall, 1982; 206 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-13-110155-2, $14.95.

Computers and Computing, An Introduction Through BASIC, Neill Graham. St. Paul, MN: West Publishing, 1982; 387 pages, 18 by 24 cm, softcover, ISBN 0-8299-0382-8, $17.95. *Instructor's Manual to Accompany Computers and Computing*, 100 pages, 18 by 24.3 cm, softcover, ISBN 0-314-63242-5. Available to instructors free of charge.

Computers That Think: The Search of Artificial Intelligence, Margaret O. Hyde. Hillside, NJ: Enslow Publishers (POB 77), 1982; 126 pages, 14.9 by 24 cm, softcover, ISBN 0-89490-079-X, $4.95.

Data Entry Without Keypunching, Martin D. Sorin. Lexington, MA: Lexington Books, 1982; 270 pages, 16.5 by 23.5 cm, hardcover, ISBN 0-669-02803-7, $27.95.

Design and Strategy for Corporate Information Services, MIS *Long-Range Planning*, Larry E. Long. Englewood Cliffs, NJ: Prentice-Hall, 1982; 18 by 24.5 cm, hardcover, 180 pages, ISBN 0-13-201707-5, $25.

Exploring the World of Computers, Donald D. Spencer. Ormond Beach, FL: Camelot Publishing, 1982; 102 pages, 15.3 by 22.9 cm, softcover, ISBN 0-89218-054-4, $5.95.

Hello, Mr Chips! Computer Jokes and Riddles, Ann Bishop. New York: Lodestar Books, 1982; 64 pages, 15.2 by 23 cm, softcover, ISBN 0-525-66782-2, $3.95.

Information Systems Concepts for Management, 2nd edition, Henry C. Lucas, Jr. New York: McGraw-Hill, 1982; 512 pages, 17 by 24.5 cm, hardcover, ISBN 0-07-038924-1, $25.95.

Inside CP/M: A Guide for Users and Programmers, David E. Cortesi. New York: Holt, Rinehart, & Winston, 1982; 571 pages, 19 by 23.5 cm, softcover, ISBN 0-03-059558-4, $22.95.

Introduction to Business Data Processing, 2nd edition, Lawrence S. Orilia. New York: McGraw-Hill, 1982; 683 pages, 19 by 24 cm, hardcover, ISBN 0-07-047835-X, $21.95.

Introduction to Microcomputers, Erik Dagless and David Aspinall. Rockville, MD: Computer Science Press, 1982; 233 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-914894-25-0, $19.95.

Microcomputer Coloring Book, Donald D. Spencer. Ormond Beach, FL: Camelot Publishing, 1982; 32 pages, 21.5 by 28 cm, softcover, ISBN 0-89218-052-8, $2.90.

Picture This: An Introduction to Computer Graphics for Kids of All Ages, David D. Thornburg. Reading, MA: Addison-Wesley, 1982; 224 pages, 21.5 by 28 cm, spiral bound, ISBN 0-201-07768-X, $14.95.

Software and Its Development, Joseph M. Fox. Englewood Cliffs, NJ: Prentice-Hall, 1982; 299 pages, 15.5 by 25.5 cm, hardcover, ISBN 0-13-822098-0, $23.95.

The Third Book of Ohio Scientific, S. Roberts. Pomona, CA: Elcomp Publishing (POB 1194), 1982; 127 pages, 13.5 by 24 cm, softcover, ISBN 3-921682-77-0, $7.95.

What Computers Can Do, 2nd edition, Donald D. Spencer. Ormond Beach, FL: Camelot Publishing, 1982; 368 pages, 15 by 23 cm, softcover, ISBN 0-89218-043-9, $12.95.

The Word Processing Book, A Short Course in Computer Literacy, Peter McWilliams. Los Angeles, CA: Prelude Press, 1982; 235 pages, 15 by 22.5 cm, softcover, ISBN 0-931580-98-7, $8.95.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

Ask BYTE

Putting Stock In Computers

Dear Steve,

I would like to use a computer for stock-market information. What software is available?

In addition to a list of stocks of my choice, I need to receive from a database charts of certain stocks that have outperformed others; e.g., the percentage of winners of the week as published in *Barron's*. I wish to be able to get a listing of certain stocks, for example:

- high cash
- high book value
- breakout of sideway movements

I may need to access up to 500 stocks each week and maintain a three-year log of historical data. Also, all disks must be on-line for automatic operation.

I would also like to have the ability to do general ledgers and to prepare W-2 forms—I have no payroll as such. My computer must function as a word processor, and I need a dot-matrix printer for utility copies of charts and correspondence-quality type for letters.

R. Miller
Brooklyn, NY

The Apple II computer will provide the necessary graphics, and a program called Market Charter will provide the rest. The Market Charter gives you:

- *high and low close bar charts*
- *trendlines, resistance lines, etc.*
- *volume charts with average volume*
- *hard copy of charts and data*
- *weekly and daily stock histories, etc.*

An updated version, to be out shortly, will include moving averages and allow an 80-stock, 100-week database. The program can link to a wire service via a modem.

This program is designed for technical analysts but is user-oriented.

*Market Charter costs $250 and is available from RTR Software Inc., 1147 Baltimore Dr., El Paso, TX 79902, (915) 544-4397. . . .***Steve**

Basic Questions

Dear Steve,

I'm presently familiarizing myself with personal computers through a local school. Some basics have struck home, but I was wondering if you could answer some questions I have.

Do you know of an elaborate form of Visicalc or Visifile that runs on the Wang word processor? If so, can it be used to evaluate incredible amounts of information—by incredible I mean well beyond the capacity of the Apple II's Visicalc? The Wang uses hard-disk drives as well as 8-inch floppy-disk drives, but a Cromemco system with 5¼-inch disk drives is available to me.

Is there a forecasting and budgeting program available that could be used in developing scenarios for more effective planning to prevent or minimize large cash surpluses that result from trying to do a full year's work in six months?

What software is available for facility maintenance, planning, and monitoring timber management, including writing reports such as environmental impact statements, energy conservation, and road development?

How far away is the technology for equipment, similar to a stereoscope, that would scan two aerial photos

and tell the user available board footage of lumber, timber types, and road locations? Upon receiving such information as current road-development costs, timber prices, and environmental costs, could this equipment literally design and size the timber-sale cost effectively?

Thanks.

Michael Montgomery
Petersburg, AK

I will try to answer your questions in the order presented:

Visicalc is a product of Visicorp (2895 Zanker Rd., San Jose, CA 95134, (408) 946-9000), which you should contact to see what computers can use its programs. If there has been sufficient demand, Visicorp may have a version available for Wang computers.

Apple Computer has introduced a program called APM (Apple Project Management) that should have the facilities you need. Check a computer store or contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (800) 538-9696; in California, (408) 996-1010.

As for facility maintenance software, your best bet would be a software house that handles CP/M-based software such as Lifeboat Associates, 1651 Third Ave., New York, NY 10028, (212) 860-0300 or Winterhalter & Associates Inc., 313 North First St., Ann Arbor, MI 48103, (313) 662-2002.

The U.S. Government has launched a number of satellites that are able to detect mineral deposits, water, and probably fish, wildlife, and vegetation. For further information, write to the Department of the Interior, C St., Washington, DC 20240. . . .**Steve**

Portable Terminals

Dear Steve,

I'm looking for a way to buy or build a smart remote terminal that I can carry with me and use to communicate with larger computers. I'd like to be able to compose, edit, and format my data before sending it along the telephone lines. You once talked about making such a thing with the Sinclair ZX80. Do you think the Sinclair and a Sony 3-inch disk drive would do the trick? I'm not much of a circuit builder, so this sounds better than starting from scratch.

Ben L. Geer
Miami, FL

Using the Sinclair ZX80 as a portable terminal with a modem and a small TV is entirely possible, but adding a disk drive is no small project (unless someone creates a disk interface).

Several good briefcase terminals are available—e.g., Matsushita, Rockwell, and Texas Instruments—as well as a few briefcase computers.

If you must have a disk drive, one possible solution is to use the Osborne 1 portable computer. It comes with disk drive, disk operating system, various types of high-level language software, and a serial port. It is about the size of a small briefcase.

Whichever method you use must be a compromise of price and performance. The Sinclair is the less expensive choice, but the Osborne 1 (or similar) computer might be the only way to satisfy your objective with any reliability. . . . **Steve**

Apple Measuring Devices

Dear Steve,

Do you know how a thermistor can be plugged into the game port, or an A/D (analog-to-digital) converter board, to give temperature readouts on the Apple II? I want to measure carbon dioxide (CO_2) gas in an air stream.

Dan Bruhns
Pine Bush, NY

Measuring the quantity of CO_2 in a gas stream is considerably more involved than measuring either its temperature or its velocity. For the former, most of the methods used are chemical in nature such as bubbling the CO_2-containing air into a solution that will cause the precipitation of calcium carbonate, which can then be measured. If extreme accuracy is required, a gas chromatograph can be used.

Measuring velocity is somewhat easier. The method that you probably would want to use is based on thermal conductivity and called a hot-wire anemometer. *This measurement is usually made by observing the change in temperature of a fine, heated wire that is conduction cooled by the gas or vapor.* . . . **Steve**

Time to Take Readings

Dear Steve,

I have been following your design projects ever since they first appeared in BYTE. I have a Radio shack TRS-80 and would like to know of a relatively simple circuit to pick up the date and time signals transmitted by radio station WWVB from Boulder, Colorado, on 60 kHz.

For a long time, I've been interested in connecting a

real-time clock to my system so that I could couple it to my environmental telemetry sensors. I plan to bury 8 geothermal sensors spaced at 10 inches (25 cm) vertically and a ninth sensor for surface temperature. Over the course of a year, I should be able to gather enough temperature data to be able to intelligently calculate how much soil I will need over an underground home that I plan to build. By having the accurate date and time, I will know the latency of a surface temperature shift, and how it will affect the temperature at different depths.

Gary R. Casady
Pinckney, MI

Using date and time signals from WWVB as a real-time clock for your TRS-80 is certainly feasible, but it requires sophisticated equipment because of the slow rise times of the time codes. The transmitted signal must be phase-controlled to the UTC (Universal Coordinated Time) time scale and the receiver must have a very narrow bandwidth (0.01 to 0.001 Hz) to extract the VLF (very-low frequency) signal from the noise level in this frequency band (60 kHz).

Rather than use all of this equipment, I would recommend the "Timedate 80" from Alpha Products, 79-04 Jamaica Ave., Woodhaven, NY 11421, (800) 221-0916; in New York, (212) 296-5916. It's totally compatible with your TRS-80 and sells for only $95, fully assembled and tested.

The accuracy of this unit is controlled by a quartz crystal and should be more than adequate for your application. From an advertisement, I can envision many other applications for this unit. . . . **Steve**

An Investment In Education

Dear Steve,

My 12-year-old son has an interest in programming. He learned BASIC II at local community colleges. His initial interest is in video games, and he has written some neat game programs.

I want to encourage his interest but cannot afford a decent microcomputer. I have an Atari Video Game system, television, and a data terminal (Texas Instruments "silent 700") that he can use. It appears all we need is memory and mass storage. Is there any device with such capability that can be integrated with this equipment?

Frank Plona
Collinsville, CT

The Atari Video Game System does have a BASIC option that consists of a cartridge and a keypad. It is supposed to enable programming in BASIC, but I am not aware of any storage device (i.e., cassette recorder) for it. It must be recognized that this system was designed as a game player and not as a programmable computer.

I would suggest that you look into one of the low-cost microcomputers on the market, such as the Commodore VIC-20, Atari 400, Radio Shack TRS-80 Color Computer, or the Sinclair ZX81.

With the exception of the $100 ZX81, these units are in the $300 to $400 price range and feature a full BASIC language, graphics, memory, and a keyboard so that programming may be accomplished both easily and efficiently.

These units offer a lot of features for the money and represent a good investment in your son's education. . . . **Steve** ■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, send your questions by electronic mail or chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

BYTE's Bits

Call for Papers

A call for papers on computers and computer applications in any area of interest to college and university instructors and administrative personnel has been issued by the California Educational Computing Consortium. The papers are to be delivered at the Seventh Western Educational Computing Conference to be held in San Francisco, California, during November 1983. Send two copies of your original paper to Professor Virginia Lashley, Coordinator of Instructional Computing, Glendale College, 1500 North Verdugo, Glendale, CA 91208. A deadline of March 1, 1983, has been imposed. ■

Event Queue

September 1982

September

Courses from Boeing Computer Services Company, various sites throughout the U.S. Among the topics to be covered are programming languages and aids, operating systems facilities, and conversational systems. A complete catalog of courses, locations, and fees is available from Boeing Computer Services Co., Education and Training Division, POB 24346, Seattle, WA 98124, (206) 575-7700.

September

Professional Development Seminars, various sites throughout the U.S. These seminars are presented by the Institute for Advanced Technology, a part of Control Data Corporation. Seminar topics include "Computer Operations Management," "Data and Site Security," and "Effective Management of Software Projects." Complete outlines can be obtained from the Registrar, Institute for Advanced Technology, Control Data Corp., 6003 Executive Blvd., Rockville, MD 20852. To register, call (800) 638-6590; in Maryland, (301) 468-8576. Information on in-house presentations is available from Pam Gallos at the address above.

September-November

Short Courses in High Technology, Centennial College of Applied Arts and Technology, Scarborough, Ontario, Canada. Among the courses offered are "Logic to Microprocessors," "Assembly-Language Programming—Intel 8080/8085," and "Industrial Robots." Course fees range from $30 to $120. These ten-week courses will be held during evening hours. For further details, contact the Coordinator Technical Programs, Centennial College, POB 631, Station A, Scarborough, Ontario M1K 5E9, Canada, (416) 439-3955.

September-December

Courses from Don White Consultants, various sites throughout the U.S. and Canada. Among the courses being offered are "Interference Control: An Introduction to Electromagnetic Interference/Radio Frequency Interference/Electromagnetic Compatibility," "Electromagnetic Control in Electronic Data-Processing Equipment," and "Tempest-Design, Control, and Testing." Course fees range from $675 to $945. For complete details, contact Don White Consultants Inc., State Route 625, Gainesville, VA 22065, (703) 347-0030.

September-December

Courses from Fairchild Camera and Instrument Corporation, Santa Clara, CA. Among the courses being offered are "F9445 Family Introduction," "Pascal for Microprocessors," and "F680X Microprocessor Family." For more information, contact Fairchild Camera and Instrument Corp., Education Center, 3420 Central Expressway, Santa Clara, CA 95051, (408) 773-2161.

September-December

IEEE Computer Society Conferences and Meetings, various sites throughout the U.S., Europe, and Asia. Among the events scheduled are "Very Large-Scale Integration and Software Engineering Workshop," "The Annual Workshop on Computing to Aid the Handicapped," and "The 1982 Real-Time Systems Symposium." For a complete listing of conferences and meetings, contact the Executive Secretary, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September-December

Information Management and Technology Seminars, various sites throughout the U.S. Among the wide variety of seminars offered by Datamation Institute are "Distributed Systems: Concepts and Management Overview," "Management of Software Engineering: Lowering Costs, Boosting Productivity," and "Data-Processing Concepts for Management and Users." Registration fees range from $595 to $795, depending upon duration and the topic covered. For details, contact Ms. Joan Merrick, Datamation Institute Seminar Coordination Office, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020. For information on in-house presentations, contact Art Gutmann, Datamation Institute for Information Management and Technology, Seminar Coordination Office, Suite 803, 331 Madison Ave., New York, NY 10017, (212) 697-2361.

September-December

Intensive Seminars for Professional Development, Worcester Polytechnic Institute campus and various sites in the New York City and Boston metropolitan areas. Some of the topics to be presented are "Project Management," "Leadership Skills and Management Tools for High-Technology Professionals," and "Microprocessors: Hardware, Software, and Applications." Fees range from $495 to $990. Complete details are available from Ms. Ginny Bazarian, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517. For information on in-house seminars, call Robert J. Hall at (617) 793-5574.

September-December

Seminars of Interest to Women Professionals, various sites around Boston, MA. This series of one- and two-day seminars is presented by Boston University Metropolitan College. Among the topics on the agenda are "Managing Word Processing to Increase Productivity and Profitability," "A Manager's Introduction to Computers and BASIC," and "Data Processing Fundamentals for Accounting and Financial Managers." The seminar fees are $325 and $495, depending on duration. For registration information, contact Ms. Joan Merrick, University Seminar Center, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020.

September 12-15

Design Engineering Technical Conference, Keybridge Marriott, Washington, DC. For information on this conference, contact the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017, (212) 644-7740.

September 13

Knowledge Engineering in the 1980s, Chicago, IL. This executive briefing provides an overview of the power and potential of artificial intelligence. It is designed to introduce executives and senior technical personnel to the concepts of knowledge engineering and knowledge systems. Topics to be covered will assist participants in assessing the utility of knowledge engineering, pinpointing areas of impact, and outlining costs and strategies for initiating knowledge-engineering projects. The fee is $750, which includes materials, luncheon, and a reception. For further information, contact Dina

Barr, Teknowledge, 151 University Ave., Palo Alto, CA 94301, (415) 327-6600.

September 13-14
VLSI (Very Large Scale Integration) Packaging Workshop, Gaithersburg, MD. This workshop is sponsored by the National Bureau of Standards and the IEEE (Institute of Electrical and Electronics Engineers). Contact George Harman, B310 Technology Building, National Bureau of Standards, Washington, DC 20234, (301) 921-3621.

September 13-15
Advanced Electronic Data Processing Auditing Concepts, Phoenix, AZ. This course is designed for experienced computer auditors. Topics to be studied include advanced computer systems control concepts and methods of evaluating controls and techniques for testing integrity and applications controls for online systems, database management systems, and distributed-processing networks. This course is presented by Coopers & Lybrand. Information is available from Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187, (312) 682-1200.

September 13-15
Hands-on Pascal Workshop, San Diego, CA. This course will provide the opportunity to learn Pascal through hands-on experience on Apple Pascal systems. Topics to be addressed include coding the language, using structured programming techniques, developing portable and maintainable software, and implementing real-time software suitable for microcomputer and minicomputer applications. The course fee is $695. For information, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, call (213) 450-2060.

September 13-16
Microcomputers as Laboratory Instruments, Cambridge, MA. This workshop is part of Technical Education Research Centers' (TERC's) Microcomputers in Education series. The cost is $300. For a brochure, contact TERC, 8 Eliot St., Cambridge, MA 02138, (617) 547-3890.

September 13-17
Computer Vision and Robotics, University of Tennessee, Knoxville, TN. This course is intended for scientists, industrial managers, and instrumentation, control, quality control, reliability, electrical, mechanical, and other design engineers. It will introduce and survey the state of the art in the use of visually guided manipulators for industrial applications. The fee is $625. Further information can be obtained from the Coordinator, Computer Vision and Robotics Course, Department of Electrical Engineering, University of Tennessee, Knoxville, TN 37996, (615) 974-3461.

September 13-17
FORTH Fundamentals, Belmont, CA. This course provides an introduction to the FORTH programming language sufficient to design and debug programs to solve real problems. Program design and documentation, FORTH arithmetic, control structures, and Meta-defining words are among the topics to be covered. The registration fee is $395. Contact Inner Access Corp., POB 888, Belmont, CA 94002, (415) 591-8295.

September 13-24
Computer Science at UCLA, University of California, Los Angeles. Sponsored by the Continuing Education in Engi-

neering and Mathematics (CEEM), this UCLA Extension program is designed for engineers, managers, and other professionals needing a concentrated overview of an up-to-date, master's level computer-science curriculum. Participants may enroll in six minicourses from a total of 18. Each unit is based on a course presented by UCLA's Computer Science Department during regular academic sessions. Each course runs for one week, two hours per day, for a total of 10 lecture hours. Hands-on experience is not provided. The fee is $1750 for the complete two-week program. Full details may be obtained from UCLA Extension, CEEM Special Programs, POB 24901, Los Angeles, CA 90024, (213) 825-5010.

September 14-15
The Future Factory, New York, NY. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

September 14-16
Mini/Micro Computer Conference and Exposition, Disneyland Hotel, Anaheim, CA. For complete details, contact Electronic Conventions Inc., Suite 410, 999 North Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965.

September 14-16
Wescon/82 High-Technology Electronics Exhibition and Convention, Anaheim Convention Center, Anaheim, CA. Among the topics to be covered are analog and digital signal processing, office automation, and semiconductor technology. For more details, contact Electronic Conventions Inc., Suite 410, 999 North Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965.

September 14-17
Applied Time Series Analysis, North Lake Hilton Hotel, Atlanta, GA. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111.

September 16-19
Applefest, Minneapolis Auditorium and Convention Hall, Minneapolis, MN. Applefest is a conference convention and exposition featuring Apple computers and Apple-related products such as software, peripherals, accessories, and publications. The admission fee is $5. Contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

September 19-24
Data Processing Training Managers' Workshop, Phoenix, AZ. This workshop is designed for people with less than 18 months' experience in coordinating data-processing training programs. Participants learn how to establish in-house education programs that will meet managements' objectives and ensure a high return on their organizations' investment in training. The fee is $850. Full details are available from Linda Hubacek, Deltak Inc., 1220 Kensington Rd., Oak Brook, IL 60521, (312) 920-0700.

September 20-21
Robot Research, Developments, and Applications in Canada, Delta Inn, Mississauga (Toronto), Ontario, Canada. This conference is jointly sponsored by the Central Ontario Chapter of Robotics International of the Society of Manufacturing Engineers (RI-SME) and the National Research Council of Canada. Technical papers and presentations will address robot research and developments, applications, con-

trollers, programming languages, sensory feedback, education, and training. Full details are available from RI–SME Conference Secretariat, 6535 Mississauga Rd., Mississauga, Ontario, L5N 1A6, Canada.

September 20-23
Logo, Cambridge, MA. This workshop is part of Technical Education Research Centers' (TERC's) Microcomputers in Education series. The cost is $300. For a brochure, contact TERC, 8 Eliot St., Cambridge, MA 02138, (617) 547-3890.

September 20-24
Advanced FORTH Applications, Belmont, CA. This course is designed for engineers, scientists, advanced technicians, and programmers associated with engineering groups. Among the topics to be addressed are engineering applications, floating point, communications, and sorting and searching. The fee is $495. Contact Inner Access Corp., POB 888, Belmont, CA 94002, (415) 591-8295.

September 20-24
Auditing in the Contemporary Computer Environment, Oklahoma City, OK. This course is designed for internal auditors and financial and data-processing professionals. A comprehensive auditing approach for computer-based systems will be presented. Topics on the agenda include how to evaluate controls, how to prepare an audit report, and how to design a program of tests using questionnaires, checklists, software tools, and flowcharts. Contact Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187.

September 20-24
COMPCON Fall '82, Capitol Hilton Hotel, Washington, DC. This conference will focus on the principles behind work-station technology, including local-area networks, operating systems, and new concepts in user interfaces. Topics of interest include reliability and availability techniques, network-wide databases, distributed architectures, network user environments, and standards. For information, contact COMPCON Fall '82, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September 20-24
Reliability Testing, Academic Center, George Washington University, Washington, DC. Some of the topics to be covered in this short course include methodologies to improve the reliability of components, equipment, and systems; sequential tests for the exponential and binomial cases; and probability plotting techniques to find the parameters of the appropriate distributions to use. The course fee is $785, which includes lecture notes. Contact Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Dept., Building 16, Room 200B, University of Arizona, Tucson, AZ 85721, (602) 626-2495, or Stod Cordelyou, Continuing Engineering Education Program, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-6106.

September 21-22
Word Processing/Information Systems Expo, Sheraton Washington Hotel, Washington, DC. This conference and exposition will address the trends and advances in the word-processing industry. Among the topics to be covered are word processing and office integration, productivity measurement, and levels of managing an organization. Further details are available from National Trade

Productions Inc., Suite 206, 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

September 21-23
Software/Expo-National, Expocenter, Chicago, IL. This show is sponsored by *Infosystems* magazine. For complete details, contact Software/Expo, Suite 400, 222 West Adams St., Chicago, IL 60606, (312) 263-3131.

September 23-25
The First International Conference and Exhibition on Medical Computer Science (Medcomp '82), Hilton Hotel and the University of Pennsylvania, Philadelphia, PA. This conference is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) Computer Society's Technical Committee on Computational Medicine. It is a transdisciplinary forum for engineers, medical professionals, and biomedical and computer scientists. Papers and exhibits will focus on topics such as the history and evolution of computers in medicine, artificial intelligence, software and systems evaluation, and signal and image processing. For additional information, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September 26-October 1
Advanced Data Processing Training Management Workshop, Sunnyvale Hilton Hotel, Santa Clara, CA. This seminar is intended for managers with a minimum of one year's experience, after completing the Data Processing Training Managers' Workshop (see September 19-24), or the equivalent in on-the-job experience. The fee is $850. Registration information is available from Linda Hubacek, Deltak Inc., 1220 Kensington Rd., Oak Brook, IL 60521, (312) 920-0700.

September 27-29
Hands-on Pascal Workshop, Washington, DC. For details, see September 13-15.

September 28-29
The Future Factory, Sunnyvale, CA. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

September 28-October 1
Applied Time Series Analysis, Marina International Hotel, Marina del Rey, CA. Contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111.

September 28-October 1
Computer Graphics, San Diego, CA. This course is designed to provide a comprehensive overview of state-of-the-art computer-graphics software and hardware and to present an integrated approach to implementation of graphics applications. Topics to be addressed include technology fundamentals, software and hardware availability and selection criteria, and raster scan, vector, and color techniques. Participants receive a take-home graphics software package. The course fee is $845. Information can be obtained from Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, call (213) 450-2060.

September 28-October 1
Computer Trade Forum, National Exhibition Centre, Birmingham, England. This trade show will bring together vendors, original equipment manufacturers, dealers, distributors, retailers, service companies, and independent sales organizations. For complete details, contact Clapp & Poliak Inc., 245 Park Ave., New York, NY 10167, (212) 661-8410. In England, contact Clapp & Poliak Europe Ltd., 232 Acton Lane, London W4 5DL, 01-747-3131.

September 28-October 1
Distributed Processing, Mini- and Microcomputer Implementations, Washington, DC. This course will cover distributed processing concepts and techniques suitable for microprocessor applications. Other topics include design requirements of distributed systems, how to partition system tasks and hardware, and how to implement data links and protocols. The fee is $845. Contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, call (213) 450-2060.

October 1982

October 1-2
The Third Annual Fall Conference on Classroom Applications of Computers, San Jose, CA. This conference is sponsored by Computer-Using Educators, a nonprofit corporation. Topics will cover all areas of curricula from preschool through post-secondary school. Workshops, field trips, school visits, commercial exhibits, and a banquet dinner with a keynote speaker will be featured. Participation in all events is by preregistration only. Conference information is available by writing to Don McKell, Computer-Using Educators, POB 18547, San Jose, CA 95158.

October 1-7
Electronics 82, Bella Center, Copenhagen, Denmark. This

will be the largest electronics fair in Scandinavia this year. It will feature demonstrations, conferences, talks, seminars, and commercial exhibits ranging from automation equipment to technical magazines. Approximately 250 exhibitors, representing almost 1000 firms, are expected. For particulars, contact Bella Center A/S, Center Blvd., DK-2300 Copenhagen S, Denmark; Tel: (01) 51 88 11; Telex: 31188 bella dk.

October 3-8
Data Processing Training Managers' Workshop, Loews Westbury Hotel, Toronto, Ontario, Canada. For details, see September 19-24.

October 4
Knowledge Engineering in the 1980s, Boston, MA. For details, see September 13.

October 4-8
Auditing in the Contemporary Computer Environment, Hartford, CT. For details, see September 20-24.

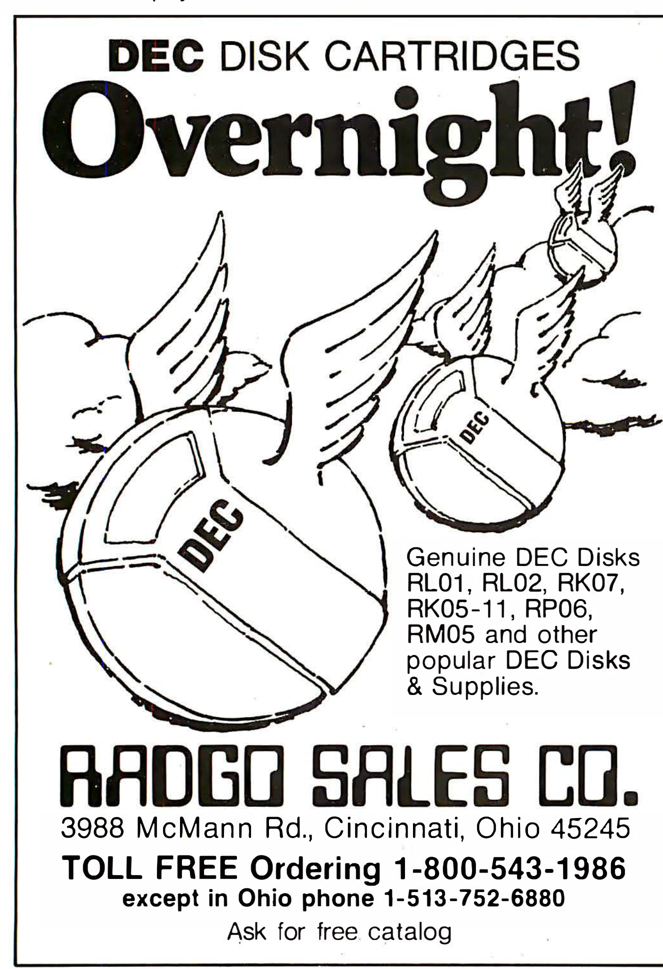
October 5-7
The Third Annual Southwest Semiconductor Exposition, Civic Plaza Convention Center, Phoenix, AZ. "Automation/Automania?" is the theme for this year's technical conference. Suppliers of equipment and materials dedicated to the semiconductor, printed-circuit board, and hybrid industries will attend. Among the issues to be explored are the latest trends in general wafer processing and printed-circuit board manufacturing, hybrids, automation, robotics, and automatic testing. Highlighting this conference will be a preventive maintenance training forum. Contact Cartlidge & Associates Inc., Suite 1014, 491 Macara Ave., Sunnyvale, CA 94086, (408) 245-6870.

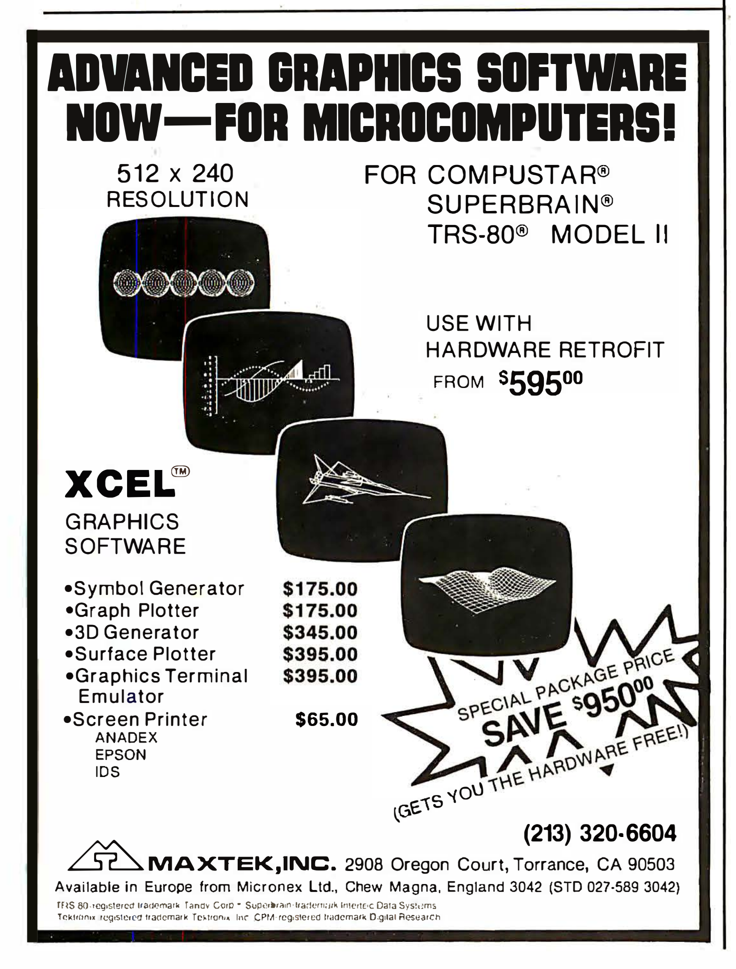
October 7-8
Workshop on Automotive Applications of Microprocessors, Hyatt Regency Hotel, Dearborn, MI. This workshop is a forum on applications of microprocessors to automobiles, trucks, vans, allied automotive products, plants, and processors. Topics of interest include engine control, engine and vehicle diagnostics, instrumentation and display, safety systems, drive-train control, plant process and quality control, and test equipment. For further details, contact S. Murtuza, Department of Electrical Engineering, University of Michigan, 4901 Evergreen Rd., Dearborn, MI 48128, (313) 593-5028 or (313) 593-5420.

October 8-11
Electronica, Hynes Auditorium, Boston, MA. This show will feature a wide variety of personal electronics equipment, including computers, electronic games, ham radios, and projection TV. For more information, contact Northeast Expositions, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

October 10-14
Association of Records Managers and Administrators (ARMA) Annual Conference and Exposition, Atlanta, GA. This is ARMA's twenty-seventh annual meeting. Word processing, data communication, and other aspects of information storage and retrieval will be examined. Additional information can be obtained from National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

October 10-14
Issue '82, Monteleone Hotel, New Orleans, LA. This is the sixth annual conference of Issue, an independent non-





profit organization of SPSS Inc. software users and coordinators. Papers will address such topics as data analysis, research training, computer graphics, and training materials and documentation. Contact the Executive Coordinator of Issue Inc., POB 11385, Chicago, IL 60611, (312) 329-2400.

October 10-15
Data Processing Training Managers' Workshop, Oak Brook Marriott Hotel, Oak Brook, IL. For details, see September 19-24.

October 11-12
Personal Computer Peripherals Market Analysis, the Anatole, Dallas, TX. The fee for this seminar is $495. Further details are available from Future Computing Inc., 900 Canyon Creek Square, Richardson, TX 75080, (214) 783-9375.

October 11-14
Info 82, Coliseum, New York, NY. More than 70 software companies and 45 hardware manufacturers are expected to display information-management-related equipment and software. Highlighting this event will be a Software Center featuring demonstrations and a consultation desk for visitors. Complete show details are available from Clapp & Poliak Inc., 708 Third Ave., New York, NY 10017, (800) 223-1956; in New York, (212) 661-8410.

October 12-13
The Future: Home, New York, NY. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

October 12-15
Distributed Processing, Mini- and Microcomputer Implementations, New York, NY. For details, see September 28-October 1.

October 13-15
Advanced Electronic Data Processing Auditing Concepts, Los Angeles, CA. For details, see September 13-15.

October 14-15
Man Machine Interface, Columbia Inn, Columbia, MD. For information, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111.

October 15-17
The Second Annual Symposium on Small Computers in the Arts, Philadelphia, PA. Papers, tutorials, workshops, a gallery display of computer-generated prints and plots, films and video tapes, and computer-generated music performances are parts of this event. Topics of interest include computer graphics and animation, computer-automated sculpture, choreography, designs, and computer-generated music. The Annual Philadelphia Computer Music Concert is the featured attraction of this symposium. Address inquiries to the Symposium on Small Computers in the Arts, POB 1954, Philadelphia, PA 19105.

October 15-19
Vidcom '82: International Telematics and Data Banks Market, Palais des Festivals, Cannes, France. The eighth annual Vidcom is expected to attract more than 7000 videocommunications and telematics professionals. Exhibitors from more than 60 countries will show products designed for the publication, transmission, reception, and creation of telematics services, including terminals, composition equipment, and communications software. Conference sessions will explore

techniques, production, and distribution costs for videotext data banks; public and professional applications; and videotext as a new advertising medium. Further details are available from Vidcom Information, 179 Avenue Victor Hugo, 75116 Paris, France; Tel: 505.14.03; Telex: 630.547 MIDORG.

October 17-21

The Thirty-first Annual Data Processing Management Association (DPMA) International Conference and Exposition, Chicago Marriott Hotel, Chicago, IL. This will be the largest show in DPMA's history. More than 85 companies will exhibit office automation technologies and data- and word-processing equipment. A full conference program is planned. Contact National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

October 18-20

Program/Project Management: Manufacturing Industries, Sheraton Poste Inn, Cherry Hill, NJ. This seminar will be led by Russell D. Archibald, author of *Managing High-Technology Programs and Projects*. Contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; in California, call (213) 824-9545.

October 18-22

Auditing in the Contemporary Computer Environment, Tulsa, OK. For details, see September 20-24.

October 18-22

Maintainability and Availability Engineering of Equipment and Systems, University of California, Los Angeles. This short course is for upper-level and product managers, designers, salespeople, field-service personnel, and for those involved in the management, conception, design, operation, and maintenance of equipment. Topics to be covered include distribution of times-to-repair components and times-to-restore equipment, the equipment mean-time-to-restore, and optimum preventive maintenance schedules for minimum total corrective and preventive maintenance cost. The fee is $825, which includes notes. A complete course outline is available from Continuing Education in Engineering and Mathematics, UCLA Extension, POB 24901, Los Angeles, CA 90024, (213) 825-4100.

October 19-20

The Future: Home, Palo Alto, CA. For information, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

October 19-21

Local Area Networks, Pinehurst, NC. This workshop is sponsored by the IEEE Communications Society, Communications Terminals and Communications Disciplines Committees. Topics to be covered include user needs, local-area networking architecture, protocols, system or network control, security, installation problems, and fault detection and monitoring. If you are interested in participating, you must submit a statement that expresses your interest, describes your background and areas of interest or expertise, details your experience or applications, and indicates which workshops you are interested in. Attendance will be limited to 100 persons, and each attendee is expected to be an active member of the group. Complete details can be obtained from Claude A. R. Kagan, Western Electric Co. Inc., POB 900, Princeton, NJ 08540.

October 21-24
EdCOM '82—The National Computer Conference and Expo for Educators, Los Angeles Convention Center, Los Angeles, CA. More than 200 seminars, workshops, demonstrations, and exhibits are planned. In-depth tutorials and hands-on sessions will be held. Topics of interest include computer-aided instruction, administrative uses of microcomputers, classroom management, programming, research applications, computer literacy, and authoring languages. Information is available from Jayne LaFountain, EdCOM '82, 2629 North Scottsdale Rd., Scottsdale, AZ 85257.

October 24-26
Texas Association for Educational Data Systems (TAEDS) Eighteenth Annual Convention, Villa Capri Hotel, Austin, TX. The conference theme is "Computer Literacy for Education, Industry, and the Community." Contact Dr. Terry Bishop, Austin ISD, 6100 Guadalupe St., Austin, TX 78752.

October 24-29
Data Processing Training Managers' Workshop, Hyatt Regency Hotel, Tampa, FL. For details, see September 19-24.

October 25-27
Advanced Electronic Data Processing Auditing Concepts, Tulsa, OK. See September 13-15 for details.

October 25-27
The 1982 ACM (Association for Computing Machinery) Annual Conference, ACM '82, Dallas Hilton Hotel, Dallas, TX. Among the topics to be addressed are programming languages, artificial intelligence, office automation, networks, graphics, computers and the handicapped, and operating, database, and distributed systems. General conference information is available from William Burns, ACM '82 Chairman, E-Systems Inc., POB 226118, Dallas, TX 75266, (214) 272-0515, ext. 3916.

October 26-28
The First IEEE Computer Society International Symposium on Medical Imaging and Image Interpretation, ISMII '82, International Congress Center, Berlin, West Germany. This symposium is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) Computer Society's Technical Committee on Computational Medicine. It will provide a transdisciplinary forum for biomedical and computer scientists, engineers, medical physicists, and physicians from universities, medical centers, industry, and government. Papers and panel discussions will examine a variety of topics, including microscope imaging, medical computer graphics, medical device regulation, computer-aided diagnosis, and image analysis systems. Equipment will be displayed. A thorough description of ISMII '82 is available from the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

October 26-29
Computer Graphics, Boston, MA. For details, see September 28-October 1.

October 26-29
Distributed Processing, Mini- and Microcomputer Imple-

 Circle 368 on Inquiry card. Circle 50 on inquiry card.

mentations, San Diego, CA. For details, see September 28-October 1.

October 26-31
The Fourth International Office Trade Fair, Orgatechnik '82, Cologne, West Germany. More than 1300 companies from 25 countries will exhibit the complete spectrum of office and information system products. Among the concurrent events planned are the KTV—Congress for Text Processing, Dafta '82—Data Protection Conference, and Telecom '82 Germany—Congress for Telecommunications in Business and Industry. For further information, contact Messe- und Ausstellungs-Ges.m.b.H Köln, POB 21 07 60, D-5000 Cologne 21, West Germany; Telex: 8 873 426 a mua d.

October 27-29
Program/Project Management: Manufacturing Industries, Hyatt Regency, Austin, TX. For details, see October 18-20.

October 28-31
Mid-Atlantic Computer Show and Office Equipment Exposition, Armory/Starplex, Washington, DC. This show is produced by Computer Expositions Inc., POB 3315, Annapolis, MD 21403 (800) 368-2066; in Maryland, (301) 263-8044.

October 28-31
Applefest, Civic Center, Houston, TX. See September 16-19 for details.

October 30-November 2
The Sixth Annual Symposium on Computer Applications in Medical Care (SCAMC), Sheraton Washington Hotel, Washington, DC. Topics to be addressed include medical informatics, health-care administration, information systems in health care, and artificial intelligence in medicine. Panel discussions, workshops, applications and methods demonstrations, and commercial exhibits are on the agenda. Highlighting this show will be the final round of the student paper competition. Information is available from Bruce I. Blum, SCAMC-Office of Continuing Education, George Washington University Medical Center, 2300 K St. NW, Washington, DC 20037, (202) 676-4285.

November 1982

November 1-3
Hands-on Pascal Workshop, New York, NY. See September 13-15 for complete details.

November 1-5
Digital Modal Analysis, Columbia Inn, Columbia, MD. Particulars are available from the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111.

November 5-7
Electronica, Arlington Park, Chicago, IL. See October 8-11 for particulars.

November 7-9
The Seventeenth Annual Conference of the New York State Association of Educational Data Systems (NYSAEDS), Americana Hotel, Albany, NY. The theme for this conference is "Moving Ahead with Instructional Computing." This conference will address the administrative uses of microcomputers and curricular issues such as computer modifications for the disabled. Hardware analyses and presentations on Logo and Pascal are planned. The conference fee is $200, which includes registration, two nights' lodging, banquets, and a luncheon. For more information, contact Gary Bruce, Program Chairperson, 55 School St., Delevan, NY 14042.

November 7-12
Advanced Data Processing Training Management Workshop, Marriott Inn North, Dallas, TX. For details, see September 26-October 1.

November 8-10
COMDEX/Europe, RAI Exhibition Center, Amsterdam, Holland. This show is expected to attract more than 500 exhibitors of systems, peripherals, software, media, supplies, and services. Details are available from the Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

November 8-10
Hands-on Pascal Workshop, Boston, MA. For details, see September 13-15.

November 8-12
Personal Microcomputer Interfacing and Scientific Instrumentation Automation, Virginia Polytechnic Institute and State University, Blacksburg, VA. This is a hands-on workshop where the participant designs and tests concepts with the actual hardware. The fee is $595. Contact Dr. Linda Leffel, C.E.C, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848.

November 9-11
The Government-Industry Data Exchange Program-GIDEP, McCormick Inn, Chicago, IL. This annual workshop is open to anyone interested in the exchange of technical information relating to engineering, failure experience, reliability and maintainability, and metrology. For more information, contact the Officer-in-Charge, GIDEP Operations Center, Corona, CA 91720.

November 9-12
Computer Graphics, New York, NY. For details, see September 28-October 1.

November 9-12
Distributed Processing, Mini- and Microcomputer Implementations, Boston, MA. See September 28-October 1 for information.

November 14-19
Data Processing Training Managers' Workshop, Westin Bay Shore Inn, Vancouver, British Columbia, Canada. For details, see September 19-24.

November 15
Knowledge Engineering in the 1980s, San Francisco, CA. See September 13 for further information.

November 15-17
Microcomputer Interfacing, Design and Programming Using the Z80/8085/8080, Virginia Polytechnic Institute and State University, Blacksburg, VA. This is a hands-on workshop with the participant designing and testing concepts with the actual hardware. The fee is $395. Contact Dr. Linda Leffel, C.E.C, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848.

November 15-19
The IX Latin American Congress on Banking Automation, ATLAPA Convention Center, Panama City, Republic of Panama. This conference is sponsored by the Latin American Federation of Banks, the Latin American Center for Banking Automation, and the Panama Banking Association. Seminars, conferences, and lectures will be complemented by exhibits of automatic data-processing and telecommunications equipment related to banking operations. For details, contact Asociación Bancaria de Panamá, Apartado 4554—Panamá 5, Republic de Panamá; Tel: 25-1863.

November 16-19
Computer Graphics, San Francisco, CA. For details, see September 28-October 1.

November 18-21
Applefest, Brooks Hall, San Francisco, CA. See September 16-19 for details.

November 18-19
The Sixth Western Educational Computing Conference, Kona Kai Club, San Diego, CA. This conference is presented by the California Educational Computing Consortium. It's intended for instructors and administrative personnel at the college and university level. The theme is "Bringing the Information Age to the Campus." Papers will address such topics as student involvement in database design, administrative computing in continuing education, the educational software dilemma, and learning economics with a microcomputer. Contact Professor Frances Grant, Center for Information and Communications Studies, California State University, Chico, CA 95929.

November 30-December 2
The 1982 Autofact 4 Conference and Exposition, Civic Center, Philadelphia, PA. This show is sponsored by the Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME). The focus will be on computer-aided design and manufacturing (CAD/CAM) and the expanding technologies of computer-integrated manufacturing (CIM) and the automated factory. Tutorials and sessions will address analysis and simulation, robotics, assembly, quality assurance, scheduling, material handling, and other related topics. Additional information is available from CASA/SME Public Relations, One SME Dr., POB 930, Dearborn, MI 48128, (313) 271-0777. ■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

A Weaving Simulator

Paul W Heiser
225 Long Meadow Circle
Pittsford, NY 14534

Before setting up a loom, a weaver wants to know what the resulting pattern will look like in the finished material. Using pencil and graph paper, he usually lays out a set of three configurations representing the tie-up, the threading, and the treadling of the loom. (An example of these input configurations, together with the resulting pattern, is illustrated in figure 1.) By marking these inputs with Xs and Os or some other combination of symbols, the weaver defines whether certain threads will lie above or below other threads. Then, by moving from points in the treadling to points in the tie-up to points in the threading, he can determine the final pattern in the woven material.

This process is a tedious one that can require anywhere

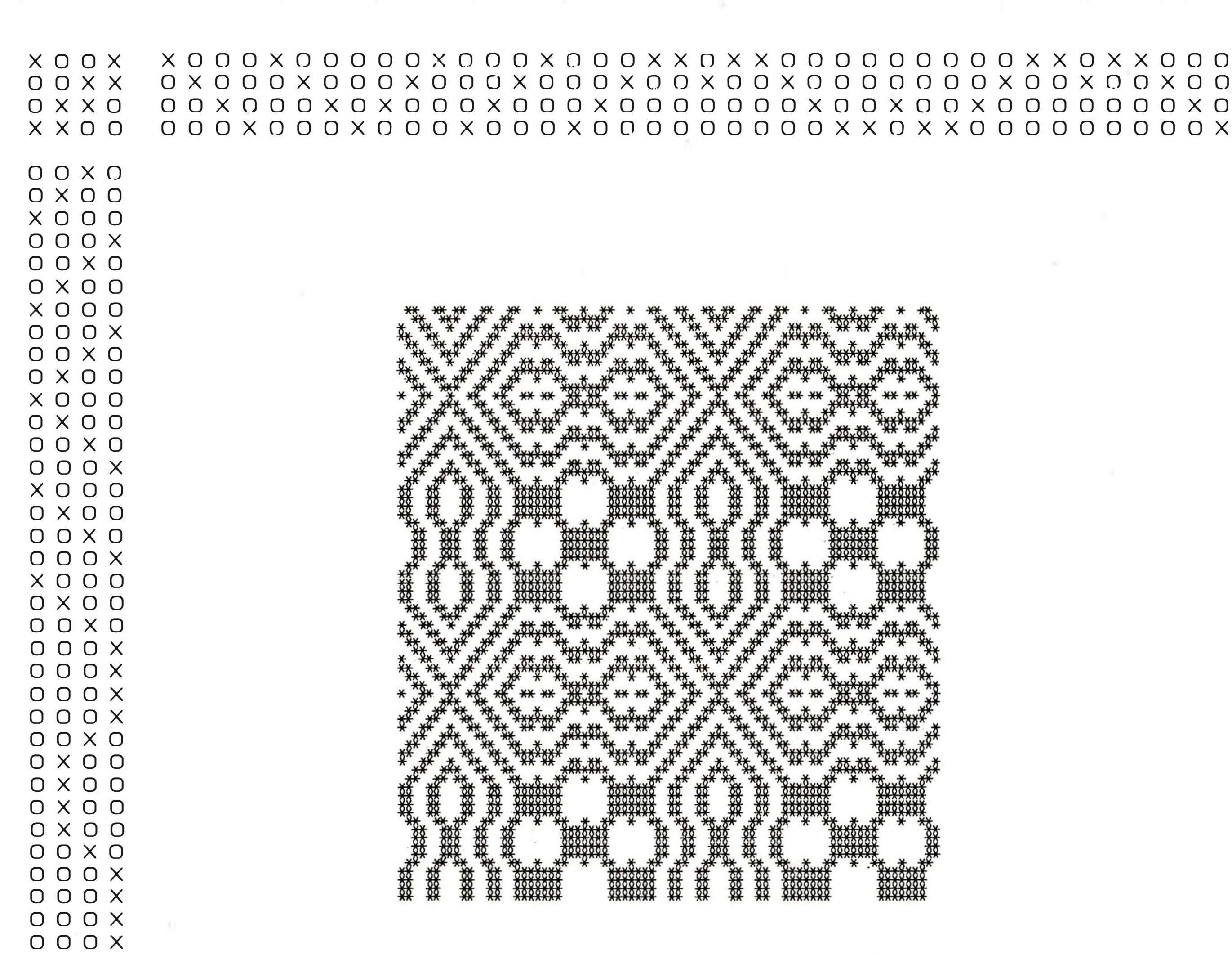


Figure 1: *Sample output of a coarse-thread pattern produced by the WEAVE program using a Diablo 1650 printer. The loom-setup matrices described in the text are shown as groups of Xs and Os. The threading matrix (E-matrix) runs across the top of the figure; the tie-up matrix (A-matrix) is the four-by-four group at the upper left. The treadling matrix (B-matrix) is the vertical group to the left, directly below the tie-up matrix. The resulting pattern is printed using asterisks (the weave pattern shown is on a different scale from the configuration matrices).*

a message to our subscribers

From time to time we make the BYTE subscriber list available to other companies who wish to send our subscribers promotional material about their products. We take great care to screen these companies, choosing only those who are reputable, and whose products, services or information we feel would be of interest to you. Direct mail is an efficient medium for presenting the latest personal computer goods and services to our subscribers.

Many BYTE subscribers appreciate this controlled use of our mailing list, and look forward to finding information of interest to them in the mail. Used are our subscribers' names and addresses only (no other information we may have is ever given).

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BYTE Publications Inc
Attn: Circulation Department
70 Main St
Peterborough NH
03458

from 20 minutes to an hour, depending on the size and complexity of the input configurations and how many mistakes the weaver makes. If he is not pleased with the resulting pattern, he may alter one or more of the inputs and repeat the process until he develops a satisfactory result.

A weaver may not realize it, but as he lays out his pattern on paper, he is actually defining and multiplying matrices. The fact that these matrices are composed of elements having ones or zeros as their values gave me the idea of writing a program to simulate the operation of a loom. The program, called WEAVE, allows use of the keyboard to define the elements of the input matrices. The computer then does all the work of multiplying the matrices to describe and display the resulting pattern.

All the data entry for WEAVE can be done in less than one minute. This is made possible by extensive use of INCHAR$ statements, which do not require the typing of Return, and by requiring definition of only the "up" threads. For a complex pattern involving very large matrices, the calculations can take several minutes, and the printout can take five or ten minutes. During all this time the user is free to do other things. The pattern that is finally printed out is far more accurate and intricate than one that could be drawn by hand in any reasonable length of time.

When I wrote the original version of WEAVE almost two years ago, I owned a printer with only normal typewriter resolution, which was too coarse to produce satisfactory patterns. Recently, however, I purchased a Diablo 1650 I/O (input/output) terminal, and its high-

Text continued on page 518

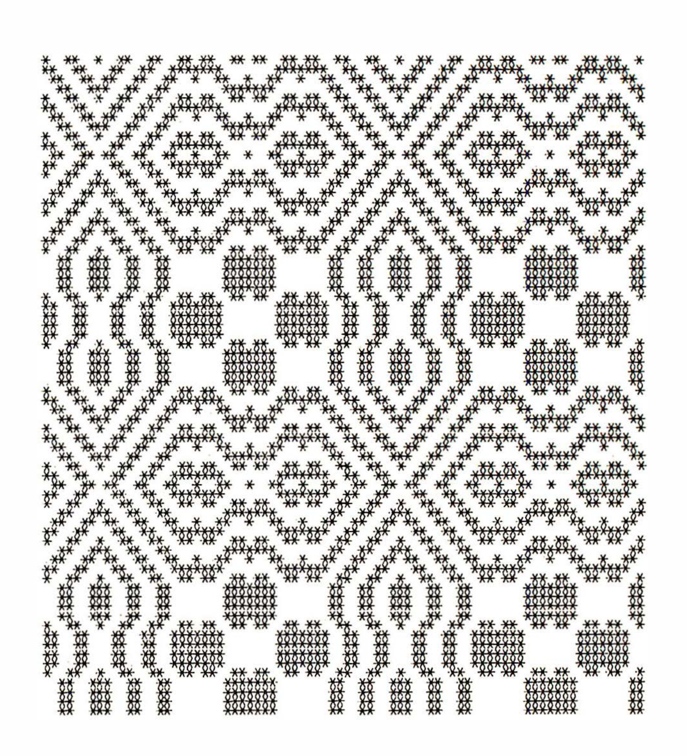


Figure 2: *This pattern is the back side (negative) of the pattern shown in figure 1.*

Listing 1: *North Star BASIC program WEAVE, which will produce a woven pattern when provided with the tie-up, threading, and treadling configuration of a loom. Extensive use is made of the INCHAR$ function, which permits single-character input without the need to type a carriage return.*

```
10 REM                    WEAVE
20 REM
30 REM  WRITTEN BY PAUL HEISER, PITTSFORD, NY.
40 REM
50 REM
60 !CHR$(11) \ REM   CLEAR SCREEN
70 FILL 3529,183 \ FILL 3569,55 \ REM   INHIBIT LL LIMIT
80 !"ROWS IN TIE-UP AND THREADING PATTERNS ARE NUMBERED FROM",
90 !" BOTTOM"\!"TO TOP."\!\!\!
100 INPUT"NUMBER OF ROWS IN TIE-UP              : ",N1
110 INPUT"NUMBER OF COLUMNS IN TIE-UP           : ",N4
120 INPUT"NUMBER OF COLUMNS IN THREADING        : ",N3
130 INPUT"NUMBER OF ROWS IN TREADLING           : ",N2
140 !\!\!"TYPE THE CHARACTER YOU WANT PRINTED ....."\!
150 !"       USE . FOR FINE THREAD"
160 !"       USE * FOR COARSE THREAD      : ",
170 C$=INCHAR$(0)\!C$\!
180 IF C$="." THEN 210
190 IF C$<>"*" THEN 140
200 N9=7\N8=4\GOTO 220
210 N9=4\N8=2
220 INPUT"NO. HORIZONTAL REPETITIONS DESIRED : ",M5
230 INPUT"NO. VERTICAL REPETITIONS DESIRED   : ",M6
240 DIM A(N1,N4),B(N2,N4),E(N1,N3),F(N2,N3)
250 E9$=CHR$(27)\M9$=E9$+"9"\H8$=E9$+CHR$(83)\L9$=CHR$(10)
260 G9$=E9$+"3"\G8$=E9$+"4"\R9$=CHR$(13)\N9$=E9$+L9$
270 B9$=CHR$(8)
280 !#1,H8$,
290 N7=1\!#1,E9$+CHR$(9)+CHR$(N7),
300 FOR J=1 TO 30\!#1," ",\NEXT\!#1,M9$,
310 N7=45
320 H9$=E9$+CHR$(31)+CHR$(N9)
330 V9$=E9$+CHR$(30)+CHR$(N8)
340 H5$=E9$+CHR$(9)+CHR$(N7)
350 FOR J=1 TO 100\NEXT
360 !#1,H9$,V9$,H5$,
370 !#1,G9$,R9$,
380 GOSUB 730\!\!
390 GOSUB 1020\!\!
400 GOSUB 880
410 !\!"PATTERN COMPUTATIONS IN PROGRESS"
420 GOSUB 1160
430 P=0
440 T=0
450 FOR L=1 TO M6
460 FOR K=1 TO N2
470 FOR M=1 TO N3
480 IF P=0 THEN 510
490 IF F(K,M)=1 THEN !#1," ", ELSE !#1,C$,
500 GOTO 520
510 IF F(K,M)=1 THEN !#1,C$, ELSE!#1," ",
520 NEXT M
530 FOR Q=1 TO 50\NEXT Q
540 !#1,R9$,L9$,
550 FOR Q=1 TO 50\NEXT Q
560 NEXT K
```

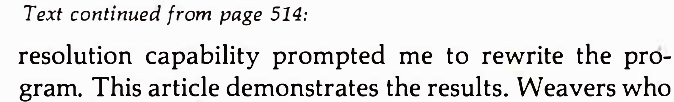
Listing 1 continued on page 516

Listing 1 continued:

```
570 NEXT L
580 T=T+1\IF T=M5 THEN 620
590 FOR J=1 TO N3\!#1," ",\NEXT J\!#1,M9$,
600 FOR J=1 TO M6*N2\FOR Q=1 TO 25\NEXT Q
610 !#1,N9$,\NEXT J\GOTO 450
620 P=P+1
630 IF P=2 THEN 680
640 FOR J=1 TO (M5-1)*N3\!#1,B9$,\NEXT\!#1,M9$,
650 V5$=E9$+CHR$(30)+CHR$(9)\!#1,V5$,
660 FOR J=1 TO 5\!#1,L9$,\NEXT\!#1,V9$,
670 GOTO 440
680 !#1,R9$,L9$,G8$,
690 !#1,V5$,H8$,
700 FOR J=1 TO 2\!#1,L9$,\NEXT
710 FILL 3529,184\FILL 3569,184 \ REM   RESTORE LL LIMIT
720 END
730 REM   SUB TO INPUT A-MATRIX ELEMENTS
740 !CHR$(11)
750 !"TIE-UP ROWS ARE NUMBERED FROM BOTTOM TO TOP."\!\!
760 !"TYPE '1' FOR THREAD UP ; TYPE '0' FOR THREAD DOWN."\!\!
770 !"TIE-UP :"\!
780 FOR J=1 TO N4
790 !TAB(10),"COLUMN ",%2I,J
800 FOR I=1 TO N1
810 !TAB(20),"ROW ",%2I,I,"  : ",
820 A$=INCHAR$(0)\!A$\A(I,J)=VAL(A$)
830 IF A(I,J)=1 THEN 850
840 IF A(I,J)<>0 THEN 810
850 NEXT I\!
860 NEXT J
870 RETURN
880 REM   SUB TO INPUT B-MATRIX ELEMENTS
890 !CHR$(11)
900 !"TREADLING COLUMNS ARE NUMBERED FROM LEFT TO RIGHT."\!\!
910 !"TREADLING :"\!
920 !"WHICH THREAD IS UP IN ",
930 FOR I=1 TO N2
940 !TAB(23),"ROW ",%2I,I," ? ",
950 T5$=INCHAR$(0)\!T5$\T5=VAL(T5$)
960 IF T5<1 THEN 940
970 IF T5>N4 THEN 940
980 FOR J=1 TO N4
990 IF J=T5 THEN B(I,J)=1 ELSE B(I,J)=0
1000 NEXTJ\NEXTI
1010 RETURN
1020 REM   SUB TO INPUT E-MATRIX ELEMENTS
1030 !CHR$(11)
1040 !"THREADING ROWS ARE NUMBERED FROM BOTTOM TO TOP."\!\!
1050 !"THREADING :"\!
1060 !"WHICH THREAD IS UP IN ",
1070 FOR J=1 TO N3
1080 !TAB(23),"COLUMN ",%2I,J," ? ",
1090 T6$=INCHAR$(0)\!T6$\T6=VAL(T6$)
1100 IF T6<1 THEN 1080
1110 IF T6>N1 THEN 1080
1120 FOR I=1 TO N1
1130 IF I=T6 THEN E(I,J)=1 ELSE E(I,J)=0
1140 NEXT I\NEXT J
```

Listing 1 continued:

```
1150 RETURN
1160 REM   SUB TO COMPUTE PATTERN
1170 FOR I=1 TO N1
1180 FOR J=1 TO N4
1190 IF A(I,J)=0 THEN 1280
1200 FOR K=1 TO N2
1210 IF B(K,J)=0 THEN 1270
1220 FOR M=1 TO N3
1230 IF E(I,M)=0 THEN 1260
1240 F(K,M)=B(K,J)*A(I,J)*E(I,M)
1250 IF F(K,M)=1 THEN F(K,M)=1 ELSE F(K,M)=0
1260 NEXT M
1270 NEXT K
1280 NEXT J
1290 NEXT I
1300 RETURN
```


Text continued from page 514:

resolution capability prompted me to rewrite the program. This article demonstrates the results. Weavers who have seen the outputs have been amazed at the ease and accuracy with which weaving could be simulated by the microcomputer.

North Star BASIC Program

WEAVE begins with FILL statements that disable the line length limitation of North Star BASIC. This disabling is necessary to prevent BASIC from inserting carriage returns at unwanted locations. Since you will want to print many more than 132 characters without a carriage return, North Star BASIC's maximum line length of 132 is not enough.

The FILL statements shown apply to a copy of North Star BASIC that has been relocated to memory address 0000. Because the program uses so much memory for the storage of matrix elements, it is not feasible to locate BASIC any higher in memory. In my Processor Technology Sol computer, I use a DOS (disk operating system) that has been relocated to hexadecimal F000 to get it out of the contiguous user-memory area.

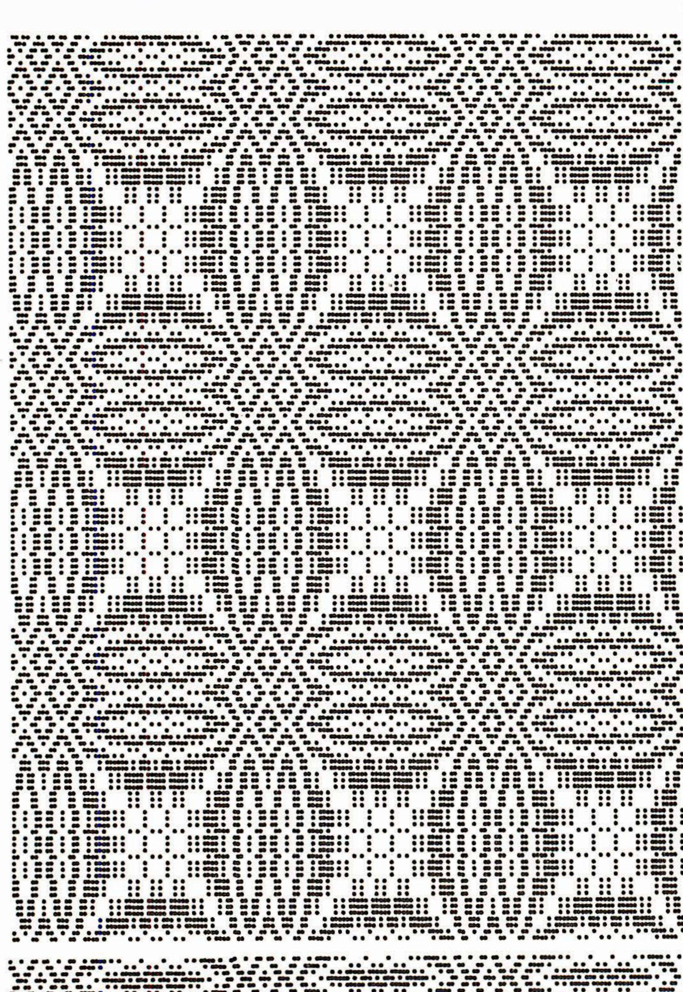
Weavers are amazed at how accurately weaving can be simulated by a microcomputer.

The program is written around the use of a Diablo 1650 printer. The Escape sequences defined in lines 250 through 270 are used for the various carriage and paper movements required by the program.

Both the treadling (B-matrix) and the threading (E-matrix) are normally elemental building blocks that are repeated many times in the generation of the woven material. These elemental blocks carry all the information required to completely define the resulting pattern. WEAVE requires the user to input only one such block, but the resulting printout can contain as many repetitions of each as desired by changing the variables M5 and M6.

Line 170 of the program permits the user to select either a fine or a coarse weaving pattern corresponding to the use of fine or coarse threads on the loom. Fine patterns are created with the "." character, while coarse ones use the "*". In both cases, the horizontal and vertical incremental spacings for the Diablo are set to appropriate values. Examples of both fine (figure 3) and coarse (figure 1) patterns accompany this article. As you can see, the program will first print out the pattern as it will appear on the front side of the material, then print the back side pattern.

The final pattern is computed in the four nested FOR . . . NEXT loops in lines 1170 through 1290. In the printout (lines 430 through 670), the variable P defines whether the front side or the back side is to be printed. The back side is, of course, simply the negative of the front side.



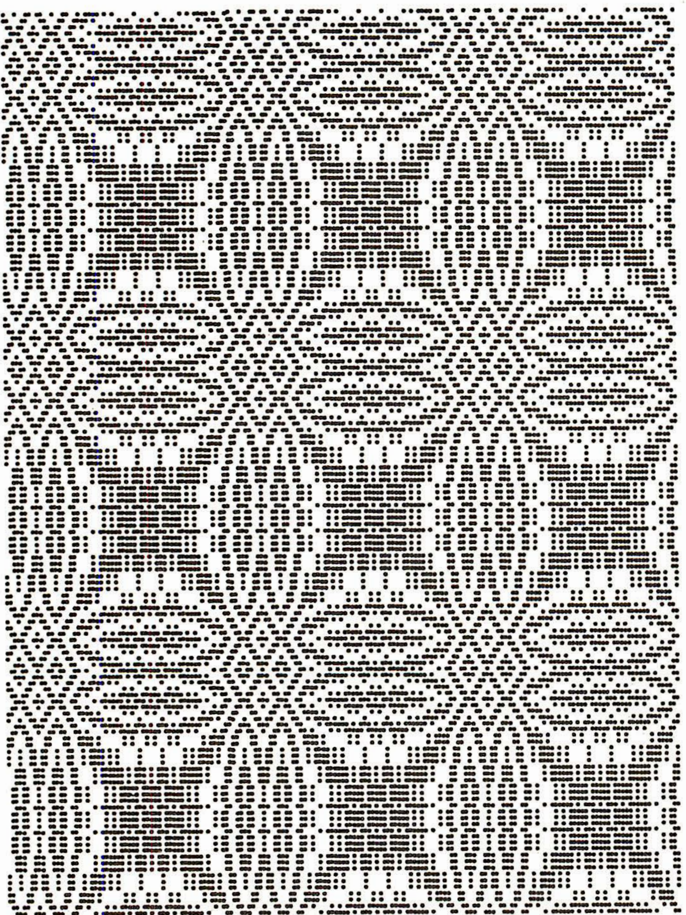


Figure 3: *Sample outputs of a fine-thread pattern produced by the WEAVE program. Both front and back patterns are shown.*

Conclusion

It is important to relocate BASIC to an address as low as possible in memory to provide maximum room for the matrices used in WEAVE. Even at a load address of 0000 you will find yourself bumping into the end of memory when you attempt to run very complex patterns. In weaving books you will find complex patterns involving combinations of input matrices as large, for example, as 8 by 8 (for tie-up), 8 by 330 (for threading) and 8 by 150 (for treadling). With one byte for each element in these matrices as well as one byte for each element of the resulting pattern matrix, you would need more than 53K bytes just for the matrix elements.

In a way, this problem points up a significant limitation of BASIC. Each matrix element involved in WEAVE can have only one of two possible values: 1 or 0. But a full 8-bit byte is required to store each element because BASIC cannot easily treat data at the bit level. Although it is beyond my ability, writing WEAVE in machine language would allow the program to handle much larger and more intricate patterns.■

Additional Notes

A-Matrix

The A-matrix is called the tie-up *by weavers.*

It is usually, but not always, a square matrix.

It can be 4 by 4, 6 by 6, 8 by 8, 10 by 10, 12 by 12, 16 by 16,or any other size depending only upon the number of harnesses on the loom.

It is usual, but not necessary, for half the threads in each column of the matrix to be "up" and the other half "down." "Up" in the program is indicated by a 1, while "down" is indicated by a 0.

B-Matrix

The B-matrix is called the foot treadling *by weavers.*

The treadling is very flexible and may actually be changed by the weaver in the course of the weaving process merely by changing the pattern of his foot motions. However, he will normally decide on a treadling pattern (or a succession of such patterns) before starting to weave so as to be able to predict the resulting design in the woven material.

The B-matrix will always have the same number of columns as the A-matrix.

The treadling is normally a repetition of elemental blocks or a repetition of a sequence of such blocks.

E-Matrix

The E-matrix is called the threading pattern *by weavers.*

It represents the configuration of threads implemented on the loom, and it cannot be easily altered during the weaving process.

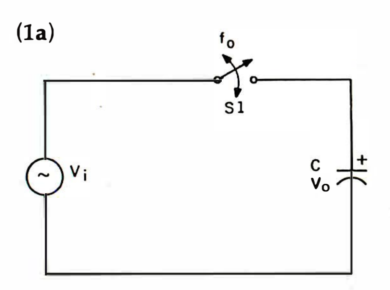
The E-matrix contains the same number of rows as the A-matrix and, like the B-matrix, may be made up of repetitive blocks or a repetitive sequence of blocks.

Turn Your Apple II into a Storage Oscilloscope

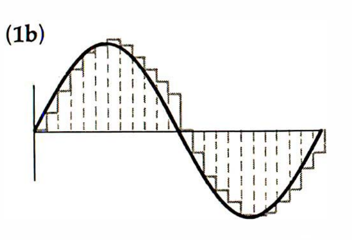
Capture "impossible" signals with an intelligent scope.

Larry Korba
301 Fifth Ave.
Ottawa, Ontario
K1S ZN4 Canada

(1a)



(1b)



(1c)

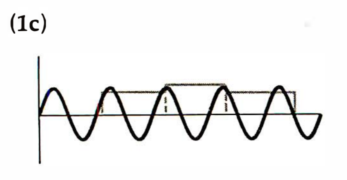


Figure 1: *The sampling concept. Figure 1a shows a simple arrangement for sampling. Figures 1b and 1c compare the results of sampling at high and low rates. Sampling at a rate less than twice the frequency of the input signal (figure 1c) produces a type of error called aliasing.*

With some simple additional hardware and software, an Apple II microcomputer can function as a storage-type oscilloscope ideally suited for transient, low-frequency signal display. An Apple II provides reasonably high-resolution graphics (160 by 280 pixels on high-resolution graphics page 1) and can be easily equipped with a Mountain Computer A/D + D/A board, an analog-to-digital and digital-to-analog converter.

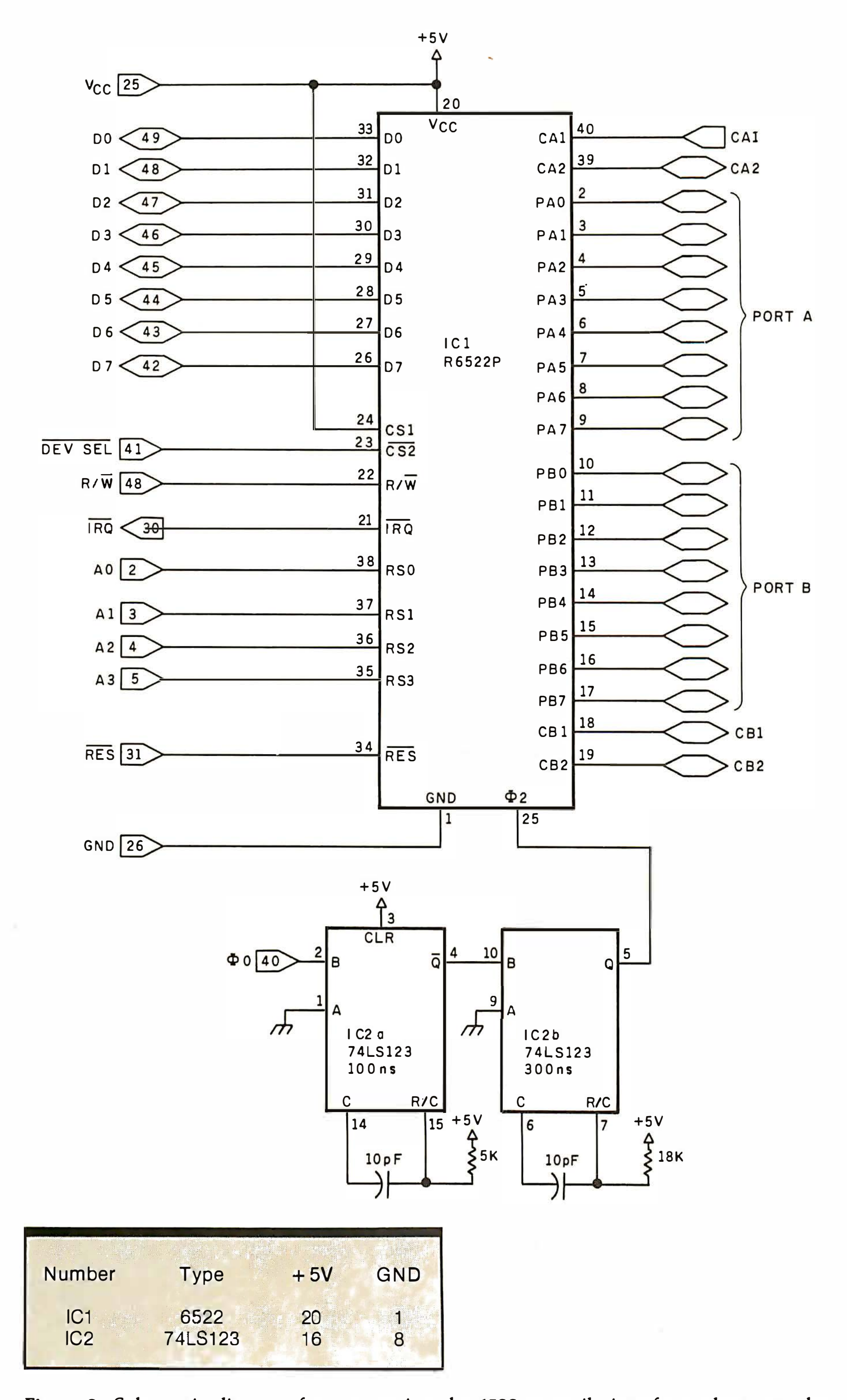
If you have ever tried to display a transient, low-frequency signal on a standard oscilloscope, you know the meaning of frustration. Often (assuming you can even trigger on the signal of interest) it may recur only once every five seconds or so, far too infrequently for you to view the trace; or you may want to observe the events that occur just prior to the trigger event—a rather difficult task using a conventional oscilloscope.

Sampling Theory

The application described here is a sampling system; that is, the input signal is sampled at regular intervals. It is therefore prone to the pitfalls of such an approach. Figure 1 illustrates the concept of a sampling system. As switch S1 toggles on and off at a rate of f_o, the sampling frequency of the system, capacitor C stores the sample result between sampling times. As long as the sampling frequency is greater than *twice the highest frequency component of the input signal,* the output of the system is representative of the input (see figure 1b). For engineers in the crowd this might sound familiar; it is called the Nyquist criterion.

You may wonder what happens if there are frequency components in V_i greater than the sampling rate. This situation is illustrated in figure 1c, where a sinusoidal signal is sampled. The result is a signal resembling the input *waveshape;* however, the output frequency of the waveform is much less than the input signal. This effect is called *aliasing.* Just as a person would use an alias to disguise identity, so in a sampling system the input signal has its frequency disguised.

To minimize aliasing, an antialias-



Number	Type	+5V	GND
IC1	6522	20	1
IC2	74LS123	16	8

Figure 2: *Schematic diagram for connecting the 6522 versatile interface adapter to the Apple II's bus.*

ing filter is usually inserted at the input to the switch to ensure that the frequency components of the input signal are restrained to the Nyquist rate. Antialiasing filters are simply low-pass filters that have very steep transitions from pass band to the cut-off frequency in order to maximize the usable input frequency range.

An alternate approach is to use no antialiasing filter at all. The major requirement for this method is knowledge of the input signal. If it is known that the input signal is well behaved and contains negligible components in the aliasing range, the sampling system will accurately represent the input signal. On the other hand, if the input signal is periodic, the aliasing effect can be used to advantage to display a signal that would normally require a much higher sampling rate. This effect is used in sampling oscilloscopes where very-high-frequency signals can be displayed by aliasing the signal down to within the bandwidth of the display electronics.

Hardware

Besides the Apple II equipped with a Mountain Computer A/D + D/A board, this application uses a 6522 VIA (versatile interface adapter) timer. The timer is used to generate interrupts at regular (sampling) intervals. In figure 2, connection of the timer to the Apple II's bus is illustrated. The main problem to be solved is the proper synchronization of the 6522 clock and the Apple II's device-select pulses. This is achieved with two one-shot multivibrators.

The 6522 has 16 addressable registers to control 2 timers, 2 I/O (input/output) ports, and 4 control lines (see description of the 6522 VIA in Rockwell's *R6500 Hardware Manual*, pages 6-1 through 6-33). For this application, timer 1 is configured for continuous-interrupt mode. This interrupt is used to signal the moment an input sample must be taken.

The Mountain Computer board is used to perform an 8-bit analog-to-digital conversion of an input signal over an input-voltage range of −5 to +5 volts (V). The actual conversion requires about 10 microseconds (μs), so it is possible to measure 16 input signals (through a built-in input multiplexer) in less than 200 μs. An input channel is read by accessing its address twice. The first reading starts the data conversion, the second reads the converted result.

Software

Three programs are used for this application: Scope, Trace, and Adcode (see listing 1). Scope is an Applesoft BASIC program that controls the overall operation of the oscilloscope. Adcode and Trace are 6502 assembly-

Listing 1: *The storage-oscilloscope programs for the Apple II. The Scope control program (listing 1a), written in Applesoft BASIC, accepts single-letter input commands to set up the interrupt-handling routine and display the signal with the proper scales. Listing 1b is an assembly-language program called Adcode, used to set up timer 1 of the 6522 versatile interface adapter to generate interrupts at regular intervals and to handle interrupts as they are generated. The assembly-language program Trace (listing 1c) is first used to scale the input data from the Adcode routine and then display it on high-resolution graphics page 1.*

Listing 1a

```
LOAD SCOPE
LIST

7 D$ =  CHR$ (4): REM  CTRL-D
12  PRINT D$;"BLOAD ADCODE.OBJ0": REM  LOAD ASSEM PRGMS
13  PRINT D$;"BLOAD  TRACE.OBJ0"
18 TIME = PRTR% = 0:LVL% = 1:MD$ = "A"
19  REM  GET SLOT NUMBER FOR THE A/D CARD
20  INPUT "SLOT NUMBER FOR A/D ";SLOT
30  IF SLOT < 1 THEN  GOTO 20
40  IF SLOT > 5 THEN  GOTO 20
50  GOSUB 255
90  PRINT "INPUT COMMAND"
100  GET A$
110  PRINT A$
120  IF A$ = "H" THEN  GOSUB 300: REM  HELP
130  IF A$ = "T" THEN  GOSUB 400: REM  SWEEP
140  IF A$ = "S" THEN  GOSUB 500: REM  SETTINGS
150  IF A$ = "P" THEN  GOSUB 600: REM  PRETRIG
160  IF A$ = "L" THEN  GOSUB 700: REM  LEVEL
170  IF A$ = "R" THEN  GOSUB 800: REM  RUN
175  IF A$ = "M" THEN  GOSUB 1500: REM  MODE SET
180  IF A$ = "C" THEN  GOSUB 255: REM   CHANNEL
185  IF A$ = "E" THEN  GOTO 200: END
190  GOTO 90: REM  LOOP
200  END : REM  SERVICE END COMMAND
255  INPUT "RECORDING CHANNEL ";CHAN%: REM  SERVICE CHANNEL CMD
260  IF CHAN% > 15 THEN  GOTO 255
270  IF CHAN% < 0 THEN  GOTO 255
280  POKE 16393,SLOT * 16 + CHAN%: RETURN
300  TEXT : REM  SERVICE HELP CMD
305  PRINT "H=HELP,T=SWEEP TIME,P=PRETRIGGER"
310  PRINT "L=LEVEL,S=SETTINGS,R=RECORD"
315  PRINT "M=MODE
320  PRINT "T,P,L,M ARE FOLLOWED BY ARGUMENT  REQUEST"
330  PRINT " ENTER 2.5 TO 1000 FOR T"
340  PRINT "        0 TO 255 FOR P"
350  PRINT "        S, C, OR A FOR M"
355  PRINT "        1 TO 254 FOR L"
360  PRINT "          FOLLOWED BY + OR - FOR SLOPE"
370  RETURN
400  INPUT "SWEEP TIME ";TIME: REM  SERVICE TIME COMMAND
410  IF TIME < 2.5 THEN  GOTO 400
420  IF TIME > 1000 THEN  GOTO 400
430 TIME = TIME * 50
440  POKE 16395, INT ((TIME / 256 -  INT (TIME / 256)) * 256 + .05) *  SGN (TIME / 256)
450  POKE 16396, INT (TIME / 256)
460  RETURN
500  TEXT : REM  SETTINGS DISPLAY
510  PRINT "SWEEP= ",(TIME / 50)
515  PRINT "PRETRIG= ",PRTR%
520  PRINT "TRIG LVL= ",LVL%,POL$
550  RETURN
600  INPUT "PRETRIGGER- ";PRTR%
610  IF PRTR% < 0 THEN  GOTO 700
620  IF PRTR% > 255 THEN  GOTO 700
640  POKE 16392,PRTR%: REM   SAVE PRETRIGGER
650  RETURN
700  INPUT "TRIGGER LEVEL ";LVL%: REM  SERVICE LEVEL CMD
710  IF LVL% < 1 THEN  GOTO 700
720  IF LVL% > 254 THEN  GOTO 700
725  POKE 16394,LVL%
730  INPUT "POLARITY( +  /  - ) = ";POL$
740  IF POL$ = "+" THEN  GOTO 770
750  IF POL$ = "-" THEN  GOTO 780
760  GOTO 730: REM  OTHERWISE LOOP
770  POKE 16656,0: RETURN
780  POKE 16656,128: RETURN
800  HGR : REM  SERVICE RUN CMD
802  HCOLOR= 7: HPLOT 0,0: CALL 62454
805  IF TIME = 0 THEN  GOTO 890
820  GOSUB 1700
830  GOSUB 1400
840  IF  PEEK (16390) = 0 THEN  GOTO 875
860  IF  PEEK ( - 16384) > 128 THEN  GOTO 1000
870  GOTO 840
875  GOSUB 1100
880  IF MD$ = "S" THEN  RETURN
881  GOTO 860
890  PRINT "NO SWEEP SET": GOSUB 400: GOTO 800
1000  POKE 49374,64: REM TURN OFF INTERRUPT
1010  RETURN
1100  PRINT "DISPLAYING, SWEEP= ",TIME / 50: REM  DISPLAY STORED DATA
1170  CALL 20480: REM  SWEEP LINE
1290  IF PRTR% = 0 THEN  GOTO 1320
1300  HCOLOR= 1
1310  HPLOT PRTR%,0 TO PRTR%,159: REM  DRAW PRETRIGGER
1320 L1 =  INT (159 - 8 * LVL% / 13): REM SCALE LEVEL
1330  HPLOT 1,L1 TO 256,L1
1350  IF MD$ = "S" THEN  RETURN : REM  CHECK FOR SINGLE STEP
1360  GOSUB 1400
1370  RETURN
1400  POKE 16655,0: REM  RESET COUNTER
1405  CALL 16384: REM INIT INTERRUPT
1406  REM  IF MODE=CONTINUOUS,DON'T WAIT FOR TRIGGER OR PRETRIGGER.
1407  IF MD$ = "C" THEN  GOSUB 1600
1410  PRINT "WAITING FOR TRIGGER"
```

Listing 1 continued:

```
1415  POKE 16390,128: REM  SET READY
1420  RETURN
1500  INPUT "SINGLE S, CONTINUOUS  C, AUTO A ";MD$: RETURN
1600  POKE 16392,0: POKE 16391,128: REM  SET PRETRIG=0 AND TRIG ON
1610 PRTR% = 0
1620  RETURN
1699  REM  PUT  IN HOR AND VERT AXIS
1700  HCOLOR= 0: FOR I = 0 TO 240 STEP 20
1710  HPLOT I,159 TO I,156
1720  NEXT I
1730  FOR I = 0 TO 159 STEP 16
1740  HPLOT 0,I TO 3,I: NEXT I
1750  HPLOT 0,80 TO 7,81: RETURN
```

Listing 1b

```
SOURCE FILE: ADCODE
0000:            * THIS IS AN INTERRUPT SERVICE PROGRAM TO
0000:            * BE USED WITH MOUNTAIN HARDWARE'S AD-DA BOARD
0000:            * INTERRUPTS ARE GENERATED BY A 6522 TIMER IN SLOT 5
0000:            *
0000:            * WHEN AN INTERRUPT OCCURS  THE DESIRED AD
0000:            * CHANNEL IS READ AND STORED IN THE STORAGE AREA ARRAY.
0000:            * IF READY IS 0,NO READ OCCURS.
0000:            * IF READY THEN DATA IS CONTINUALLY STORED IN ARRAY
0000:            * IF THE INPUT DATA IS ABOVE THE TRIGGER LEVEL
0000:            *  THEN THE AD DATA IS WRITTEN INTO ARRAY ONLY FOR
0000:            * THE NUMBER OF CHARACTERS INDICATED BY THE PRETRIGGER
0000:            * AMOUNT.
0000:            * ONCE ALL THE DATA IS COLLECTED, READY, TRIG AND AN INTERNAL
0000:            * SOFT COUNTER ARE ZEROED.  THE TIMER1 INTERRUPT IS
0000:            * TURNED OFF TO ALLOW FAST USER THROUGHPUT
0000:            * "COUNT1" INDICATES THE START POINT OF DATA
0000:            * EQUATES
0000:            * INPUTS ARE:
0000:            *   READY  INDICATES READY TO START
0000:            *   TRIG   INDICATES TRIGGER LEVEL
0000:            *   MAXCNT INDICATES PRETRIGGER LEVEL
0000:            *   TICLA  INDICATES TIMER1 INTERRUPT TIME
0000:            *   TICHA  HI BYTE OF TIMER 1
0000:            *   POL    INDICATES TRIGGER POLARITY
0000:            *   CHNL   CHANNEL OF A/D BOARD TO READ
0000:            *
0000:            * OUTPUTS ARE:
0000:            *   READY  INDICATES WHEN ALL DATA IS COLLECTED
0000:            *   ARRAY2 STORES THE 256 DATA BYTES COLLECTED
0000:            *
03FF:            IRQAH    EQU   $03FF
03FE:            IRQAL    EQU   $03FE
C0D4:            TICL     EQU   $C0D4
C0D5:            TICH     EQU   $C0D5
C0DB:            ACR      EQU   $C0DB
C0DD:            IFR      EQU   $C0DD
C0DE:            IER      EQU   $C0DE
00C0:            INTEN    EQU   $C0
0040:            INTDIS   EQU   $40
0000:            *
----- NEXT OBJECT FILE NAME IS ADCODE.OBJ0
4000:                     ORG   $4000
4000:4C D0 41    START    JMP   INIT
4003:4C E9 41             JMP   INIT2        ENTRY POINT NOT USED
4006:            *
4006:            * USER ALTERABLE BUFFERS
4006:            *
4006:            READY    DS    1            16390 READY INDICATOR
4007:            *          0-NOT READY,128- READY
4007:            TRIG     DS    1            16391 TRIGERRED INDICATOR
4008:            *          0- NOT TRIGERRED,128, TRIGGERED
4008:            MAXCNT   DS    1            16392 PRETRIGGER AMOUNT
4009:            CHNL     DS    1            16393 SLOT*16+CHANNEL
400A:            TRLVL    DS    1            16394 TRIGGER LEVEL 0-255
400B:            TICLA    DS    1            16395 TIMER VALUE
400C:            TICHA    DS    1            16396 TIMER VALUE HI
400D:            *
400D:            ARRAY2   DS    256          16397
410D:            *
410D:00          SAMPLE   DFB   $00          TEMP SAVE AREA FOR SAMPLE
410E:00          COUNT    DFB   $00          COUNT TO END OF SAMPLE
410F:00          COUNT1   DFB   $00          16655 CYCLING LOOPCOUNTER
4110:00          POL      DFB   $00          16656 TRIG POLARITY
4111:            *     0= +VE POL,$80= -VE TRIG
4111:00          IND1     DFB   $00          16657 INDICATES READY FOR TRIG
4112:00          IND2     DFB   $00          INTERNAL READY INDICATOR
4113:00          MAXCN1   DFB   $00          INVERTED MAX COUNT
4114:            *
4114:            * INTERRUPT SERVICE
4114:            *
4114:8A          INTSRV   TXA                  GET X AND Y
4115:48                   PHA                  AND SAVE ON STACK
4116:98                   TYA                  ACC SAVED IN ADDR $45
4117:48                   PHA
4118:AD DD C0             LDA   IFR          GET FLAG
411B:10 03                BPL   INTW         RETURN IF NOT TIMER1 INTERRUPT
411D:0A                   ASL   A
411E:30 03                BMI   INTX         IF TIM1 CONT
4120:4C C9 41    INTW     JMP   RTI1         OTHERWISE RETURN
4123:AD D4 C0    INTX     LDA   TICL         RESET TIMER FLAG
4126:            * GET SAMPLE
4126:AE 09 40             LDX   CHNL         GET CHANNEL
4129:BD 80 C0             LDA   $C080,X      GET SAMPLE
412C:EA                   NOP
412D:EA                   NOP
412E:EA                   NOP                WAIT FOR CONVERSION TO FINISH
412F:EA                   NOP
4130:EA                   NOP
4131:BD 80 C0             LDA   $C080,X      GET DATA
4134:8D 0D 41             STA   SAMPLE       SAVE FOR LATER
4137:            *
4137:            * SEE IF READY FOR DATA COLLECTION
4137:AD 06 40             LDA   READY
413A:D0 03                BNE   INTY         CONT IF READY
```

Listing 1 continued on page 524

Listing 1 continued:

```
413C:4C C9 41               JMP  RTI1      OTHERWISE EXIT
413F:            *
413F:            * CHECK IF INTERNALLY READY
413F:AD 12 41    INTY       LDA  IND2
4142:F0 6E                  BEQ  INT02     JUST STORE MORE IF NOT
4144:            * CHECK IF SIGNAL TRIGERRED
4144:AD 07 40               LDA  TRIG
4147:D0 45                  BNE  INT01     STORE DATA IF TRIG
4149:            * SEE IF READY FOR TRIG
4149:AD 11 41               LDA  IND1
414C:30 20                  BMI  INT0C     JUMP IF READY
414E:AD 10 41               LDA  POL       CHECK POLARITY
4151:F0 10                  BEQ  INT0B     JUMP IF +VE
4153:AD 0D 41               LDA  SAMPLE    CHECK FOR INPT > TRIG
4156:CD 0A 40               CMP  TRLVL
4159:90 57                  BCC  INT02
415B:A9 80       INT0A      LDA  #$80
415D:8D 11 41               STA  IND1      SET UP INDICATOR
4160:4C B2 41               JMP  INT02
4163:AD 0D 41    INT0B      LDA  SAMPLE
4166:CD 0A 40               CMP  TRLVL
4169:90 F0                  BCC  INT0A     CHECK FOR INPT<TRIG
416B:4C B2 41               JMP  INT02     OTHERWISE CONTINUE
416E:            * CHECK TRIGGER LEVEL
416E:AD 10 41    INT0C      LDA  POL       CHECK POL
4171:10 0B                  BPL  INT0D     JMP IF +VE
4173:AD 0D 41               LDA  SAMPLE
4176:CD 0A 40               CMP  TRLVL     CHECK FOR -VE TRIG
4179:90 0B                  BCC  INT0E     JUMP IF TRIG
417B:4C B2 41               JMP  INT02
417E:AD 0D 41    INT0D      LDA  SAMPLE    CHECK FOR +VE TRIG
4181:CD 0A 40               CMP  TRLVL
4184:90 2C                  BCC  INT02     JUMP IF NOT TRIG
4186:A9 80       INT0E      LDA  #$80
4188:8D 07 40               STA  TRIG      INDICATE TRIGGERED
418B:4C B2 41               JMP  INT02
418E:AD 0E 41    INT01      LDA  COUNT
4191:CD 13 41               CMP  MAXCN1
4194:90 19                  BCC  INT01A    JUMP IF PRETRIG DONE
4196:A9 00                  LDA  #00
4198:8D 07 40               STA  TRIG      ZERO BUFFERS
419B:8D 06 40               STA  READY
419E:8D 0E 41               STA  COUNT
41A1:8D 11 41               STA  IND1
41A4:8D 12 41               STA  IND2
41A7:A9 40                  LDA  #INTDIS
41A9:8D DE C0               STA  IER       DISABLE INTERRUPTS
41AC:4C C9 41               JMP  RTI1
41AF:EE 0E 41    INT01A     INC  COUNT     POINT TO NEXT STORE LOCATION
41B2:AD 0F 41    INT02      LDA  COUNT1
41B5:A8                     TAY
41B6:CD 08 40               CMP  MAXCNT
41B9:90 05                  BCC  INT03     JUMP IF NOT ENOUGH
41BB:A9 80                  LDA  #$80
41BD:8D 12 41               STA  IND2      SET SET UP INDICATOR
41C0:AD 0D 41    INT03      LDA  SAMPLE    GET SAMPLE
41C3:99 0D 40               STA  ARRAY2,Y  SAVE DATA IN ARRAY
41C6:EE 0F 41               INC  COUNT1    INC STORE POINTER
41C9:68          RTI1       PLA
41CA:A8                     TAY             RESTORE REGISTERS
41CB:68                     PLA
41CC:AA                     TAX
41CD:A5 45                  LDA  $45       RESTORE ACC
41CF:40                     RTI
41D0:            *
41D0:78          INIT       SEI
41D1:A9 41                  LDA  #<INTSRV
41D3:8D FF 03               STA  IRQAH     SET UP INTERRUPT VECTOR
41D6:A9 14                  LDA  #>INTSRV
41D8:8D FE 03               STA  IRQAL
41DB:A9 00                  LDA  #00       SET UP USER BUFFERS
41DD:8D 06 40               STA  READY
41E0:8D 0F 41               STA  COUNT1
41E3:8D 0E 41               STA  COUNT
41E6:8D 07 40               STA  TRIG
41E9:A9 00       INIT2      LDA  #00
41EB:18                     CLC
41EC:ED 08 40               SBC  MAXCNT
41EF:8D 13 41               STA  MAXCN1    SAVE INVERTED PRETRIG
41F2:            *
41F2:A9 C0                  LDA  #$C0      SET UP ACR
41F4:8D DB C0               STA  ACR
41F7:AD 0B 40               LDA  T1CLA     SET UP TIMER 1
41FA:8D D4 C0               STA  T1CL
41FD:AD 0C 40               LDA  T1CHA
4200:8D D5 C0               STA  T1CH
4203:A9 C0                  LDA  #INTEN    ENABLE INTERRUPTS
4205:8D DE C0               STA  IER
4208:D8                     CLD
4209:58                     CLI
420A:60                     RTS

*** SUCCESSFUL ASSEMBLY: NO ERRORS

C0DB ACR        400D ARRAY2     4009 CHNL       410E COUNT
410F COUNT1     C0DE IER        C0DD IFR        4111 IND1
4112 IND2       41E9 INIT2      41D0 INIT       418E INT01
41AF INT01A     41B2 INT02      41C0 INT03      415B INT0A
4163 INT0B      416E INT0C      417E INT0D      4186 INT0E
  40 INTDIS       C0 INTEN      4114 INTSRV     4120 INTW
4123 INTX       413F INTY       03FF IRQAH      03FE IRQAL
4113 MAXCN1     4008 MAXCNT     4110 POL        4006 READY
41C9 RTI1       410D SAMPLE    ?4000 START      C0D5 T1CH
400C T1CHA      C0D4 T1CL       400B T1CLA      4007 TRIG
400A TRLVL
```

Listing 1 continued:

```
                40 INTDIS          C0 INTEN          03FE IRQAL          03FF IRQAH
?4000 START     4005 READY       4007 TRIG         4008 MAXCNT
 4009 CHNL      400A TRLVL       400B TICLA        400C TICHA
 400D ARRAY2    410D SAMPLE      410E COUNT        410F COUNT1
 4110 POL       4111 IND1        4112 IND2         4113 MAXCN1
 4114 INTSRV    4120 INTW        4123 INTX         413F INTY
 415B INTOA     4153 INT0B       415E INTOC        417E INTOD
 4136 INTOE     418E INT01       41AF INT01A       41B2 INT02
 41C0 INT03     41C9 RTI1        41D0 INIT         41E9 INIT2
 C0D4 TICL      C0D5 TICH        C0DB ACR          C0DD IFR
 C0DE IER
```

Listing 1c

```
0000:                      LST  ON
0000:         * THIS PROGRAM USES THE APPLESOFT HIGH
0000:         * RESOLUTION GRAPHIC SUBROUTINES TO DISPLAY
0000:         * THE OUTPUT OF THE RECORDING STAGE OF THE SCOPE PROGRAM
0000:         * THE INPUTS TO THIS PROGRAM ARE:
0000:         *     1. ARRAY2-THE ARRAY IN WHICH THE A/D DATA IS STORED
0000:         *     BY THE INTERRUPT SERVICE ROUTINE
0000:         *     2. COUNT1-THE OFFSET INTO ARRAY2 POINTING TO THE
0000:         *     FIRST BYTE OF THE LAST RECORDUNG
0000:         * THE OUTPUTS ARE:
0000:         *     1. ARRAY2-THE 256 VALUES OF ARRAY2 ARE SCALED TO FIT THE 160 HIGH
0000:         *     HGR SCREEN 1.
0000:         *     2. ARRAY1-A SORTED ARRAY OF ARRAY2 VALUES SORTED
0000:         *     FOR VERTICAL DISPLAY ON THE 280X160 HI RES SCREEN 1
0000:         *     3. A DISPLAY OF THE RECORDED DATA ON THE APPLE SCREEN
0000:         *
0000:         * GENERAL EQUATES
0000:         *
0000:         * HI RESOLUTION GRAPHIC ROUTINES
0000:         *
F53A:         HLIN    EQU  $F53A      LINE WRITE
F457:         HPLOT   EQU  $F457      POSITION DOT
00E4:         SETHCOL EQU  $E4        COLOUR BYTE LOCATION
0000:         *
0000:         * EQUATES FOR BUFFERS IN ADCODE
0000:         *
400D:         ARRAY2  EQU  $400D
410F:         COUNT1  EQU  $410F
0000:         *
0000:         *
0000:         * START OF PROGRAM
0000:         *
----- NEXT OBJECT FILE NAME IS TRACE.OBJ0
5000:                 ORG  $5000
5000:4C 07 51         JMP  START
5003:         * USER BUFFERS
5003:00       CTR     DFB  $00        X COORD COUNTER
5004:00       CTR1    DFB  $00        INPUT DATA INDEX
5005:FF       ARRAY1  DFB  $FF        SAVE AREA FOR OLD DATA
5006:                 DS   255
5105:00       OUTL1   DFB  $00        DIV OUTPUT
5106:00       OUTA    DFB  $00        INPUT TO DIVIDE
5107:AD 0F 41 START   LDA  COUNT1     GET DATA INDEX
510A:8D 04 50         STA  CTR1       SAVE FOR INDEXING DATA
510D:AD 05 50         LDA  ARRAY1
5110:C9 FF            CMP  #$FF       CHECK FOR FIRST TIME THRU
5112:F0 22            BEQ  CLR        IF BYTE =FF,CLEAR
5114:A9 00    ST1     LDA  #00
5116:8D 03 50         STA  CTR        ZERO COUNTER
5119:20 8D 51         JSR  CALC       ADJUST INPUT DATA
511C:20 43 51 LOOP    JSR  ERASE      ERASE OLD LONE
511F:20 60 51         JSR  DRAW       DRAW NEW LINE SEG
5122:AD 03 50         LDA  CTR        GET OUTPUT PTR
5125:C9 FF            CMP  #255       IF NOT POINTING TO LAST BYTE
5127:90 F3            BCC  LOOP       LOOP
5129:AE 04 50 RTS1    LDX  CTR1       INCR POINT
512C:AC 03 50         LDY  CTR        GET OLD DATA POINTER
512F:BD 0D 40         LDA  ARRAY2,X
5132:99 05 50         STA  ARRAY1,Y
5135:60               RTS
5136:         * CLEAR ARRAY
5136:A2 FF    CLR     LDX  #$FF       SET UP LOOP COUNT
5138:A9 00            LDA  #00
513A:9D 05 50 CLRLP   STA  ARRAY1,X   ZERO ARRAY
513D:CA               DEX              POINT TO NEXT LOCATION
513E:D0 FA            BNE  CLRLP
5140:4C 14 51         JMP  ST1        RETURN TO MAIN LINE
5143:         * ERASE OLD LINE
5143:A9 7F    ERASE   LDA  #127       SET WHITE
5145:85 E4            STA  SETHCOL
5147:AE 03 50         LDX  CTR
514A:A0 00            LDY  #$00       ZERO Y REG
514C:BD 05 50         LDA  ARRAY1,X   GET DATA
514F:20 57 F4         JSR  HPLOT
5152:AE 03 50         LDX  CTR
5155:E8               INX              POINT TO NEXT DATA POINT
5156:BC 05 50         LDY  ARRAY1,X   GET DATA
5159:8A               TXA
515A:A2 00            LDX  #00        ZERO X REG
515C:20 3A F5         JSR  HLIN       DRAW LINE RTS
515F:60               RTS
5160:         * DRAW NEW LINE
5160:A9 00    DRAW    LDA  #0         SET BLACK
5162:85 E4            STA  SETHCOL
5164:AE 04 50         LDX  CTR1
5167:AC 03 50         LDY  CTR        READY TO SAVE NEW AS OLD
516A:BD 0D 40         LDA  ARRAY2,X   GET NEW DATA
516D:99 05 50         STA  ARRAY1,Y   STORE AS OLD
5170:A0 00            LDY  #00
5172:AE 03 50         LDX  CTR        GET CURRENT POS
5175:20 57 F4         JSR  HPLOT
5178:EE 04 50         INC  CTR1       POINT TO NEXT INPUT BYTE
517B:AE 04 50         LDX  CTR1       POINT TO NEXT BYTE
517E:BC 0D 40         LDY  ARRAY2,X   GET NEXT DATA
5181:EE 03 50         INC  CTR        POINT TO NEXT POSITION
5184:AD 03 50         LDA  CTR        GET X COORD
5187:A2 00            LDX  #00
5189:20 3A F5         JSR  HLIN
518C:60               RTS
518D:         * CALCULATE 159-3*(INPUT DATA)/13
```

Listing 1 continued on page 526

Listing 1 continued:

```
518D:              100 * SCALING FOR THE DISPLAY
518D:              101 CALC     EQU  *
518D:AE 04 50      102          LDX  CTR1        POINT TO START OF INPUT DATA
5190:A0 00         103          LDY  #$00        LOOP 256 TIMES
5192:BD 0D 40      104 LOOP1    LDA  ARRAY2,X    GET DATA
5195:8D 05 51      105          STA  OUTA        SET UP FOR CALC
5198:20 C9 51      106          JSR  DIV13       DIV BY 13
519B:20 B9 51      107          JSR  MULT8       MULT RESULT BY 8
519E:20 E3 51      108          JSR  DIV1
51A1:AD 06 51      109          LDA  OUTA        GET REMAINDER
51A4:C9 07         110          CMP  #07
51A6:90 03         111          BCC  CALC1
51A8:EE 05 51      112          INC  OUTL1       INCR OUTPUT
51AB:38            113 CALC1    SEC
51AC:A9 9F         114          LDA  #159        SUBTRACT RESULT FROM 159
51AE:ED 05 51      115          SBC  OUTL1
51B1:9D 0D 40      116          STA  ARRAY2,X
51B4:E8            117          INX
51B5:88            118          DEY
51B6:D0 DA         119          BNE  LOOP1       LOOP 255 TIMES
51B8:60            120          RTS
51B9:98            121 MULT8    TYA
51BA:48            122          PHA               SAVE Y ON STACK
51BB:A0 03         123          LDY  #03         SET UP LOOP COUNT
51BD:0E 05 51      124 MULTL    ASL  OUTL1       MULT BY 2
51C0:0E 06 51      125          ASL  OUTA        MULT BY 2
51C3:88            126          DEY               DECR LOOP COUNT
51C4:D0 F7         127          BNE  MULTL
51C6:68            128          PLA               GET Y
51C7:A8            129          TAY               RESTORE
51C8:60            130          RTS
51C9:              131 * DIVIDE BY 13
51C9:A9 00         132 DIV13    LDA  #00         ZERO RESULT
51CB:8D 05 51      133          STA  OUTL1
51CE:AD 06 51      134          LDA  OUTA        GET DIVIDEND
51D1:C9 82         135          CMP  #130        COMPARE AGAINST 10*13
51D3:90 0E         136          BCC  DIV1        JUMP IF <130
51D5:AD 06 51      137          LDA  OUTA
51D8:38            138          SEC
51D9:E9 82         139          SBC  #130        SUBTRACT 130 FROM INPT
51DB:8D 06 51      140          STA  OUTA
51DE:A9 0A         141          LDA  #10
51E0:8D 05 51      142          STA  OUTL1       SAVE PART OF RESULT
51E3:98            143 DIV1     TYA
51E4:48            144          PHA
51E5:A0 00         145          LDY  #00
51E7:38            146 DIV2     SEC
51E8:AD 06 51      147          LDA  OUTA        GET INPUT
51EB:C9 0D         148          CMP  #13         CHECK IF DIVIDEND TOO SMALL
51ED:90 08         149          BCC  DIV3        EXIT IF DIV<13
51EF:E9 0D         150          SBC  #13
51F1:8D 06 51      151          STA  OUTA
51F4:C8            152          INY
51F5:10 F0         153          BPL  DIV2        ALWAYS JUMP
51F7:98            154 DIV3     TYA
51F8:18            155          CLC
51F9:6D 05 51      156          ADC  OUTL1       ADD LOOP COUNT TO RESULT
51FC:8D 05 51      157          STA  OUTL1       SAVE RESULT
51FF:68            158          PLA               RESTORE Y REG
5200:A8            159          TAY
5201:60            160          RTS
5202:              161          LST  ON

*** SUCCESSFUL ASSEMBLY: NO ERRORS

5005 ARRAY1        400D ARRAY2        51AB CALC1         518D CALC
5136 CLR           513A CLRLP         410F COUNT1        5003 CTR
5004 CTR1          51E3 DIV1          51C9 DIV13         51E7 DIV2
51F7 DIV3          5160 DRAW          5143 ERASE         F53A HLIN
F457 HPLOT         5192 LOOP1         511C LOOP          51B9 MULT8
51BD MULTL         5106 OUTA          5105 OUTL1        ?5129 RTS1
  E4 SETHCOL       5114 ST1           5107 START
```

language routines for interrupt handling and graphics display functions, respectively.

The Adcode program has two entry points. You call the routine commencing at the label Start to initialize buffers used by the interrupt subroutine and set up the interrupt vector and all registers controlling the operation of timer 1. The label Intserv indicates the start of the interrupt-service routine. This is the point to which program control eventually passes when an interrupt occurs. A flowchart for this program is shown in figure 3; key labels are indicated.

The overall purpose of Adcode is to read converted analog data and store it in a 256-byte array (Array2). Start of the data-record period is indicated by the Ready indicator byte. Once this byte is set to hexadecimal 80, the interrupt routine will store converted data in Array2 on future interrupts until the input signal satisfies the trigger requirements. When the trigger occurs, more data is stored in the array to allow display of the data following the trigger. This is done by collecting a number of data points equal to 256 minus the pretrigger count.

This interrupt-service routine allows a maximum sampling rate of approximately 8 kilohertz (kHz), which leaves about 50 percent of the processor time for execution of the Scope program.

Scope is an Applesoft BASIC program that provides a method for altering the controls of the display. It provides for input of certain functions by way of single-letter commands:

- **T:** (sweep-time setting) indicates the number of milliseconds (ms) per horizontal display division; ranges from 2.5 to 1000 ms/division.
- **P:** (pretrigger amount) a number between 0 and 255 that indicates the number of samples to be displayed before the trigger event occurs.
- **L:** (level and slope) a number between 1 and 254 that indicates the level and slope at which the trigger occurs (the slope is either + or −, to indicate which way the input singal should pass through the level to indicate a trigger).
- **S:** (settings) a display of the present sweep time, pretrigger amount, trigger level, and polarity.
- **H:** (help) provides a list of commands and a brief description of each.
- **R:** (run) starts the recording process.
- **M:** (mode) allows the selection of a variety of triggering modes, including continuous, automatic, and single sweep. (Continuous mode will display the contents of the storage buffer as it is filled; no attempt is made to trigger on the input signal. Automatic mode will attempt to trigger on the input signal and display the data using the pretrigger information; once another trigger occurs, the process is automatically repeated. In the single-sweep mode, only one triggered recording of the input data will be made and displayed; the program then returns to input command mode.)
- **C:** (channel) allows the user to change the selection of the input A/D channel for recording; the user can select from channels 0 to 15.
- **E:** (end) will end execution of the Scope program, returning control to the Applesoft monitor.

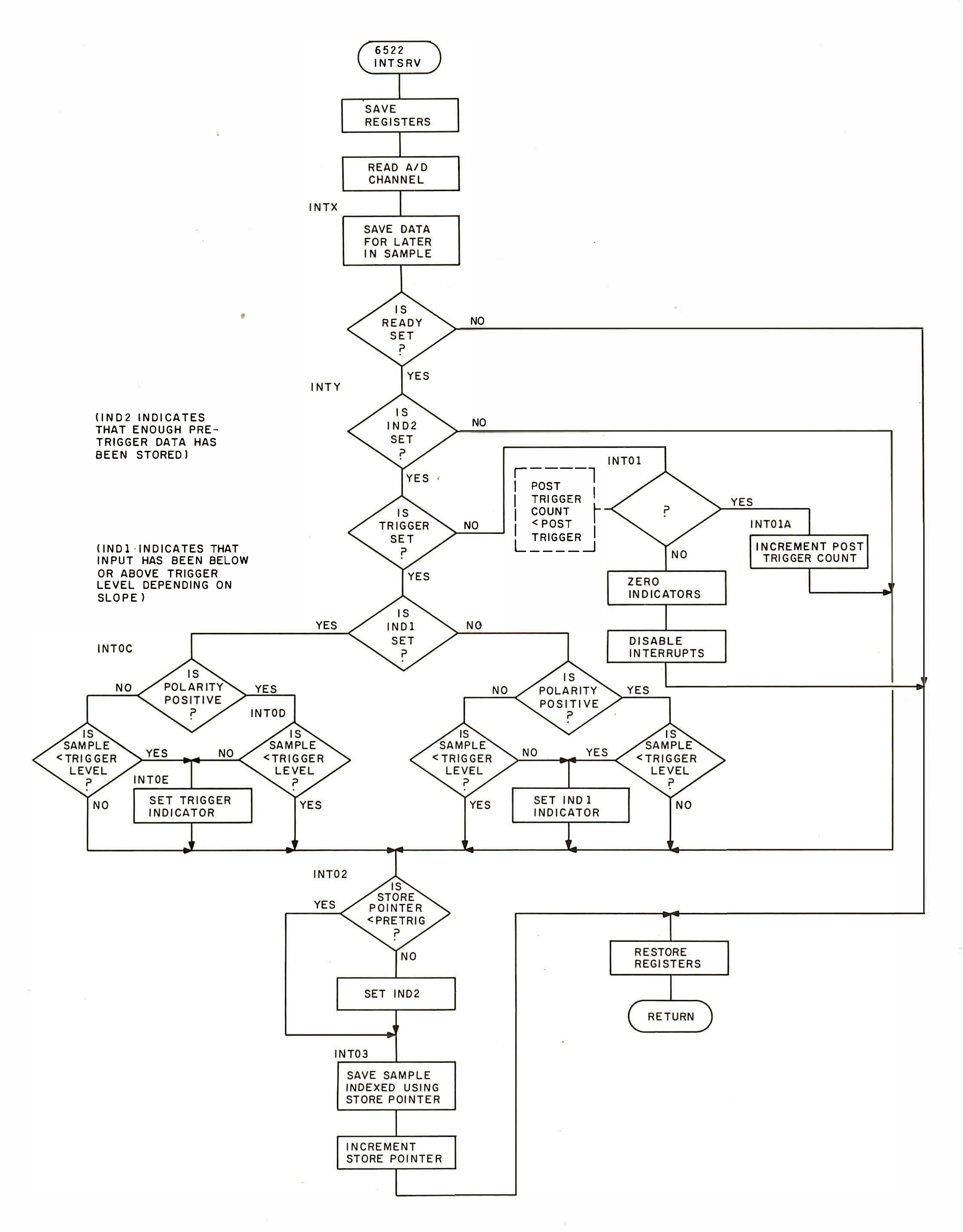


Figure 3: *Flowchart of the interrupt-service routine within Adcode (see listing 1b). This routine stores data in Array2 until the trigger conditions are met and the post-trigger samples are accumulated.*

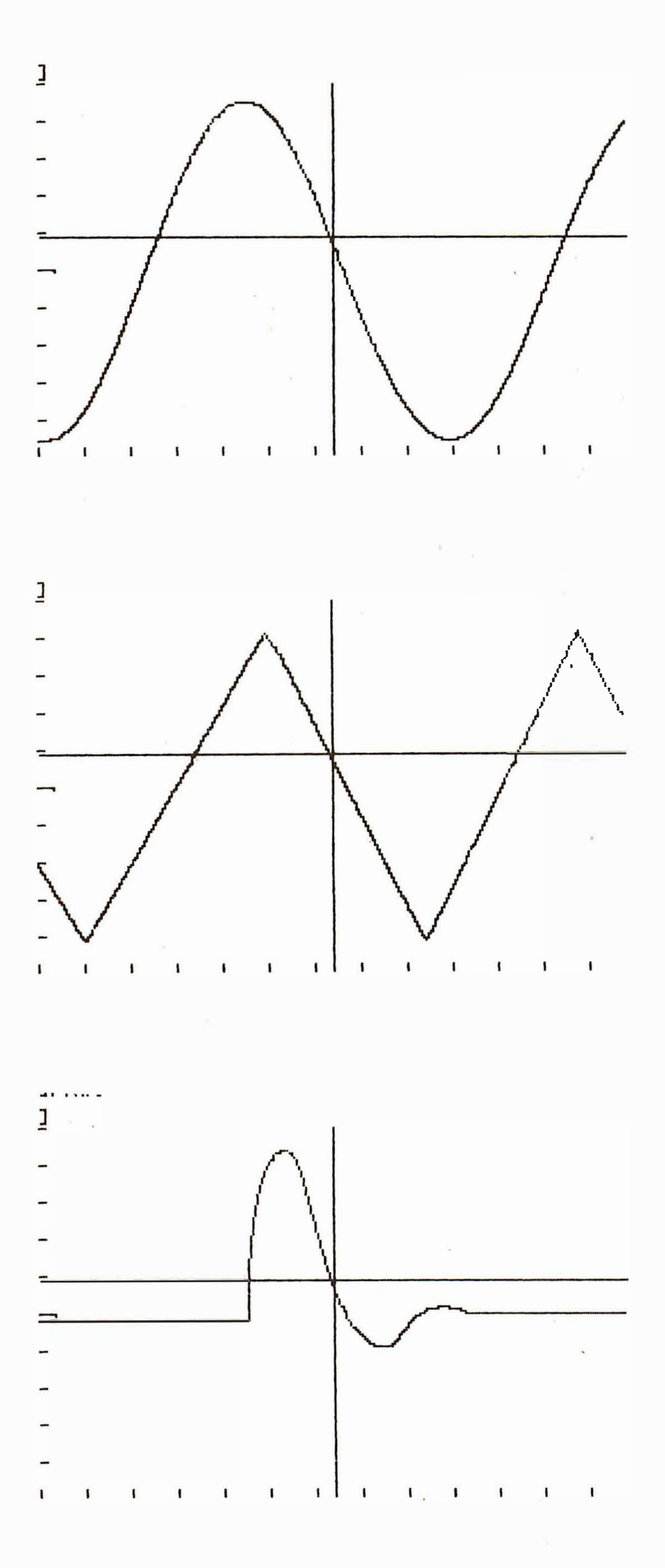


Figure 4: *Examples of printed output of the Scope program (the same image is seen on the Apple II's screen). The vertical divisions along the left side of the display represent 1 volt per division. The horizontal scale is indicated on the text line of the display.*

When the RUN command is given and automatic mode has been selected, the timer is set and enabled, and the message WAITING FOR TRIGGER appears on the screen. The ready indicator is also set, allowing the Intserv routine to start storing converted data and look for a trigger at the appropriate time. If, during the recording process, any key of the Apple keyboard is depressed, control is passed back to the command portion of the program to allow decoding of the character entered. When the recording cycle is finished, the ready indicator is reset, and the message DISPLAYING SWEEP = *xx* is displayed on the video display. The number *xx* is the horizontal time-scale factor in milliseconds per division. Control now passes to the Trace subroutine.

The other commands are processed in a straightforward fashion. The first action performed by the Trace subroutine is scaling of the input data for display within the 160 vertical divisions of the Apple's screen. Since the data can have one of 256 levels and the display screen is only 160 pixels high, the input data must be appropriately scaled for display. The Trace program uses two 256-byte data buffers, one containing the data just recorded and the other containing the data last displayed. Applesoft graphics subroutines are called to erase the old data on the screen and display the newly acquired data on a point-by-point basis. Once all 255 lines have been drawn on the screen, control passes back to the Scope control program.

It is possible to write an Applesoft BASIC program to scale and display the data; however, display of a single trace would take several seconds. This assembly-language version takes less than a second to trace the stored waveform on the Apple's monitor.

Application

The Apple II storage oscilloscope is best suited for display of low-frequency, transient signals. To use the program, simply enter RUN SCOPE. Scope will be loaded and it, in turn, will load the object files for

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As featured in Byte Magazine, July, August, 1981.

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Listing 2: *Sample execution of the Scope program.*

```
]RUN SCOPE
SLOT NUMBER FOR A/D 4
RECORDING CHANNEL 1
INPUT COMMAND
P
PRETRIGGER- 110
INPUT COMMAND
L
TRIGGER LEVEL 165
POLARITY( +  /  - ) = -
INPUT COMMAND
T
SWEEP TIME 3
INPUT COMMAND
H
H=HELP,T=SWEEP TIME,P=PRETRIGGER
L=LEVEL,S=SETTINGS,R=RECORD
M=MODE
T,P,L,M ARE FOLLOWED BY ARGUEMENT REQUEST
 ENTER 2.5 TO 1000 FOR T
       0 TO 255 FOR P
       S, C, OR A FOR M
       1 TO 254 FOR L
         FOLLOWED BY + OR - FOR SLOPE
INPUT COMMAND
M
SINGLE S, CONTINUOUS  C, AUTO A A
INPUT COMMAND
S
SWEEP=          3
PRETRIG=        110
TRIG LVL=       165          -
INPUT COMMAND
R
WAITING FOR TRIGGER
DISPLAYING, SWEEP=           3
```

the two 6502 assembly-language programs, Adcode and Trace. Listing 2 shows a sample run of the Scope program. Examples of the display are shown in figure 4.

Further Improvements

The major advantage of the system is the software triggering. You can make trigger-point determination as complex as necessary. It is possible, for instance, to arrange a trigger at a sudden peak or trough of the input signal simply by saving two previous samples and indicating a trigger when the last data point is larger or smaller than the present sample and the second-to-last point. With some software changes, you can also store more than 256 bytes of information, allowing display of data long before or long after the trigger event. However, increasing the complexity of the interrupt-service routine may mean increasing its execution time, which will decrease the maximum sampling rate possible.

Data can be written to disk or tape for later recall, display, or analysis by special routines (e.g., spectral analysis). You can get a multitrace facility by altering Adcode and Trace to handle multiplexing of input data and displaying multiple lines.

To improve the vertical resolution of the scope display, the time and voltage axes can be interchanged. This will provide a total potential vertical resolution of 280 pixels (although only 256 points will be used), but only 192 sample points can be displayed at a time using high-resolution graphics page 2.

Conclusion

The program and hardware described above will convert an Apple II computer into a digital storage oscilloscope. This system provides a scope useful for capturing low-frequency, transient signals (maximum sampling rate of 8 kHz). Higher-frequency periodic signals can be displayed; however, the input-frequency range must be known before recording the signal. Many changes are possible using the present program structure to tailor the instrument to a user's particular need. ■

Pickles & Trout CP/M for the TRS-80 Model II

Hal Smith
Smith Micro Enterprises
POB 439
Monett, MO 65708

Pickles & Trout has come up with an implementation of CP/M for the TRS-80 that leaves all others far behind. Our firm purchased a Model II because of its local service availability. We quickly found that TRSDOS (the standard operating system for the Model II) was not adequate for our needs. Looking for an alternative, we discovered Pickles & Trout CP/M 2.2, an adaptation of Digital Research's CP/M for the TRS-80 Model II. (For a comparison of TRSDOS vs. CP/M features, see table 1.)

Documentation

The package comes with the usual seven manuals from Digital Research Corporation as well as Pickles & Trout's own 150-page manual, which is concise and well written. (At this writing, Pickles & Trout is preparing a new manual.) All of the major stumbling blocks of getting a CP/M-based system started up are covered in Pickles & Trout's manual. It also provides useful examples of actual programs.

In the area of user interface with CP/M, the Pickles & Trout manual is fairly complete and refers those who need more information to the appropriate section of the Digital Research manuals. As well, the Pickles & Trout manual explains the exact function of each peripheral device and specifies the control codes that operate the screen functions, the characters that the keyboard sends, the details of the serial port drivers, and the Centronics parallel port drivers.

The concern that Pickles & Trout has for the new CP/M user is obvious. The section "Getting on the Air" (i.e., getting started) takes the first-time user from turning the computer on to making a working master system disk. Pickles & Trout manuals are a joy to read.

At a Glance

Name
Pickles & Trout CP/M 2.2 for the TRS-80 Model II

Type
CP/M operating system

Manufacturer
Pickles & Trout
POB 1206
Goleta, CA 93116
(805) 685-4641

Price

Standard version	$185
Double-sided version	$220
Cameo hard-disk version	$250
Corvus hard-disk version	$250
Manuals only	$ 35

(cost may be applied to purchase of Pickles & Trout CP/M 2.2 for a 6-month period)

Format
8-inch disk, soft sector

Language
Z80 and 8080 assembly

Computer
Radio Shack TRS-80 Model II, 32 or 64K bytes of memory

Documentation
Standard 7 CP/M manuals; more than 150 pages of bound manual and supplements from Pickles & Trout

Audience
TRS-80 Model II CP/M users

They explain the underlying concepts in terms that the beginning user can understand, but with enough detail so that the sophisticated user can use the full features and functions of the Model II.

TRSDOS 2.0a	Pickles & Trout CP/M version 2.2	Comments
AGAIN	none	
ANALYZE	STAT	partial equivalent (note 1)
APPEND	PIP	
ATTRIB	STAT	
AUTO	AUTOEXEC	
BUILD	ED	ED more powerful than BUILD
CLEAR	none	
CLOCK	various TIME functions	
CLS	none	
COPY	PIP, FASTCOPY	
CREATE	none	
DATE	various DATE functions	
DEBUG	DDT	
DO	SUBMIT, XSUB	printer echoes display
DUAL	Control-P	
DUMP	SAVE	
ECHO	none	
ERROR	none	
FORMS	SETMISC	
FREE	STAT	
HELP	none	
HOST	PIP	(note 2)
I	Control-C	warm boot
KILL	ERA	
LIB	none	
LIST	TYPE, DUMP	
LOAD	DDT	
MOVE	PIP, FASTCOPY	
PAUSE	none	
PRINT	TYPE, PIP	
PROT	none	
PURGE	ERA	
RECEIVE	PIP	(note 2)
RENAME	REN	
RESET	none	
SCREEN	none	
SETCOM	SETUP	
SPOOL	DESPOOL	output from disk text file only
STATUS	none	
TIME	various TIME functions	
T	none	
VERIFY	none	(note 3)

Notes
1. *FCBS* from PL/I User's Group adds remaining features.
2. Subject to certain limitations in data format and flexibility.
3. Normally always verify after write; may be enabled in PIP at user option.

Table 1: *A comparison of the functions of TRSDOS 2.0a (Model II) to its nearest analogs in Pickles & Trout CP/M.*

Hardware Options

Pickles & Trout has provided some things that Tandy did not. An option (at $175) is a board called the CCB-II, which supports a clock, a calendar, and a bell tone, and fits into the Model II card cage. For an additional $5, Pickles & Trout provides a TRSDOS disk with support routines for the CCB-II for both CP/M and TRSDOS.

The system features are listed in table 2. In addition to the standard Radio Shack configuration, Pickles & Trout supports double-density double-sided drives and the

Disk Storage
- 596K bytes on single-sided disks
- 1.2 megabytes on double-sided disks
- 10-80 megabytes on hard-disk controller
- automatic density select on floppy drives
- multidrive emulation on single-drive system
- floppy head step times of 3, 6, 10, and 15 milliseconds, by drive

System
- 8K-byte system, leaving up to 56K bytes for transient programs
- system size can be changed to leave area for special routines
- 27 additional special functions
- provision for real-time clock service routines
- full compatibility with existing CP/M software
- over 20 additional utilities for the Model II

Input/Output
- full-function video-display control, including:
  - carriage return, linefeed, tab, backspace, delete
  - clear screen, clear to end of line, clear to end of screen
  - insert and delete line
  - cursor left, right, up, and down
  - reverse video and graphics
  - wrap or nonwrap at end of screen line
  - direct cursor addressing, direct access to screen
  - read cursor x-y location, read character at cursor
  - scroll protect top of screen (0 to 23 lines)
  - set size and blink of cursor, set blink rate of cursor
  - set cursor off or on

Serial Ports
- normal CP/M access
- special application direct access
- handshaking: ETX/ACK, XON/XOFF, clear-to-send and data-carrier-detect
- data rates: 110, 134.5, 150, 300, 600, 1200, 2400, 4800, 9600 bps
- stop bits: 1, 1½, 2
- parity: even, odd, none
- word length: 5, 6, 7, 8 bits
- RS-232C status line RTS and DTR: high or low

Keyboard
- 64-character type-ahead buffer
- "Break" key enable/disable
- Hold key functional for standard console I/O

Clock/Calendar
- standard system functions
- 0.01 second resolution
- hardware date and time support available (CCB-II option)

Centronics Port
- formfeed emulation
- automatic linefeed emulation
- automatic linefeed after carriage return may be software suppressed

Table 2: *An overview of the features available in Pickles & Trout CP/M for the TRS-80 Model II.*

Cameo hard-disk or Corvus hard-disk systems with up to four drives. They are currently examining implementation of support for the Radio Shack hard disk as well.

Using Pickles & Trout CP/M, the system can be set up for from one to four drives in a normal configuration. After the sign-on message with the copyright notices, it asks you how many drives the system has. If the answer is one, the system lets you use four logical drives, even though there is only one physical drive, and it prompts you whenever a change is needed. This is the simplest method I've seen to support multiple-disk operation on one drive.

In addition to the (often cryptic) BDOS (basic disk operating system) error message, Pickles & Trout's error interface returns a status byte, which directs you to the manual for additional information about the error.

Utilities

Pickles & Trout has made its utilities as goof-proof as possible without making them difficult to use. The utilities are uniform in approach to operation and are all well prompted.

The RESIZER utility, which Pickles & Trout supplies instead of SYSGEN and MOVCPM, generates a CP/M system that can vary from 20 to 64K bytes in 256-byte increments. This allows you to set aside space above CP/M for special drivers, patches, applications, or other routines. A 64K-byte system gives a 56K-byte transient program area. Also, Pickles & Trout provides the information that makes it possible for you to find the amount of space between the end of the operating system and the end of memory. Short routines may reside there; the only shortcoming is that whenever the system changes, the available address space changes.

RESIZER will run only from the licensed issue disk. It will not run if it is not on the original systems disk. This prevents you from backing up the operating system without the original systems disk and makes it difficult for a pirate to make a copy. And with the serial number buried in the operating system, tracing pirated copies is easy.

The FORMAT utility lets you format either a standard single-density CP/M disk or a double-density disk. The double-density disk holds 600K bytes, of which 596K bytes are user-accessible; 4K bytes are used for the directory maximum of 128 entries. The double-density format is the standard for Pickles & Trout CP/M. This gives Model II users at least 60 percent more usable disk space than they would have with the TRSDOS 2.0a.

Along with the FORMAT utility are the disk test and certification routines. DENSITY lets you check a disk for a specified density and change the density flag if needed. DDTEST and SDTEST are destructive tests of the media. They write several patterns of bits to all tracks of the disk, recording hard and soft errors on the screen as well as displaying the progress of the test. DDCHECK and SDCHECK are similar, but nondestructive, tests of the media which also notify you of potential media-related errors.

Other Utilities

The SETUP utility is a useful tool for working with the serial ports. It can be used to change the data rate, number of bits in a word, stop bits, parity, and handshaking protocol for the serial ports. It also displays the current serial port status without altering the values. In addition, SETUP displays the current IOBYTE status and allows it to be changed.

SETUP is the easiest utility that you can find. It uses the keyboard arrow keys to move the cursor from option to option. The current option is highlighted in reverse video. An advantage of using reverse video is that it is easy to identify the current settings. You can then press Control-Q to exit, Control-S to change a parameter; or you can press Control-X to set the parameters and then exit SETUP.

STAT, PIP, ED, ASM, DDT, SUBMIT, and XSUB are the standard transient programs furnished by Digital Research. Pickles & Trout's explanations of them are the most concise that I have seen, and this includes some of the new CP/M books.

SETTIME, SETDATE, TIME, and DATIME are utilities to set and return the system time and date. If you have the CCB-II board installed, SETCCB allows you to set that device also. I have found it advantageous for some applications to set the system time and date to *virtual* values, while the CCB-II maintains the actual values.

This lets you "fib" to an application program and then restore the proper time and date later. SYNCHRO is a program that will synchronize the system clock and the CCB-II. This ensures that the system clock will remain accurate, even though there is some slippage (about 0.16 percent) between the system time and the actual elapsed time. There is a provision in the time-of-day clock to roll the system date forward if the system time goes past midnight, as well as a provision for leap years.

Another nice utility that Pickles & Trout offers in the area of timekeeping is the information you need to perform a timer-interrupt routine. The system clock ticks in intervals of 0.01 seconds. The interval to call the interrupt-service routine can be from 1 to 65,535 ticks or 0.01 to 655.35 seconds. This makes polling functions, response time limits, and other time-measurement functions easier to implement at the CP/M system level.

SETMISC allows you to change all of the system's miscellaneous I/O parameters from the console.

Pickles & Trout hasn't forgotten overseas users, either. A function called HERTZ allows you to set up the system for 50 or 60 Hz operation.

Another Pickles & Trout utility, SETMISC, lets you change all of the system's miscellaneous I/O (input/output) parameters from the console. In the screen area, line-wrap of the console can be set on or off, the cursor size varied, or the cursor blink rate altered. In addition, the cursor can be turned off and the Z80 I/O port of the CCB-II can be set.

For disk drives, SETMISC allows the drive-head stepping times to be set individually, by drive, for a 3-, 6-, 10- or 15-ms (millisecond) step rate. This lets you fine-tune your system performance. We have a rare Model II that can step all drive heads at 6 ms. Our local Radio Shack dealer's Model II will step at 6 ms for the built-in drive, but his outboard drives will not move faster than 10 ms.

SETMISC allows the Centronics parallel port options to be configured very conveniently. Tandy printers supply an automatic linefeed (LF) after a carriage return (CR). Many other printers do not, so most of the available software adds a linefeed after the carriage return. If you are using a Tandy printer, it will give double-spaced output. Pickles & Trout's Centronics driver can be set to ignore that extra linefeed. One minor bug that exists when you are suppressing the extra linefeeds is in LLISTing MBASIC programs. Linefeeds in program lines are reversed to LF/CR pairs instead of the normal CR/LF pair. This confuses the printer driver, so the LLISTing of MBASIC programs with the embedded linefeeds will include additional line spaces if the automatic linefeed suppression is selected.

For printers that do not have the formfeed function, Pickles & Trout's driver will count lines and perform a formfeed emulation by generating the appropriate number of linefeeds. The form length can be set for between 0 and 254 lines. In addition, a second counter will count the number of lines before an automatic formfeed. This function can also be enabled or disabled for automatic formfeed.

Both SETUP and SETMISC alter system parameters temporarily. If you want to make these changes permanent, Pickles & Trout CP/M provides a function called IOFREEZE which permanently sets the I/O and system parameters into the system disk. It also sets the number of disks query to default to 0 through 4. If you answer from 1 through 4, the system assumes you have that number of drives. If, however, 0 is specified, the system interrogates the console at a *hard boot*.

FASTCOPY copies all files of all users and is much more efficient than PIP for moving files.

Speaking of boots, I would define three types: warm, cold, and hard. The warm boot is the standard one where only the Console Command Processor (CCP) is reloaded (i.e., a Control-C). The cold boot reloads the whole CP/M system, including the CCP, the BDOS, and the BIOS (basic input/output system). The difference between a hard boot and a cold boot is that a hard boot will occur only if the boot ROM (read-only memory) in the Model II is first enabled and then the CP/M system is loaded and begins execution—typically upon pressing the Reset button. A cold boot can be called by a standard system function, but the boot ROM is not enabled as it would be if the Reset button were engaged.

Pickles & Trout provides an automatic execution function called AUTOEXEC. This function provides for automatic loading of a CCP command and invocation by the system. The options are *never*, *cold only*, and *warm and cold* boots, which is why I define Pickles & Trout CP/M to have three types of boots. If the AUTOEXEC is selected for warm and cold, the function is invoked at either cold or warm boot. If the AUTOEXEC time is set to cold, the only time that you see the function is at initial start-up or after the Reset switch has been pressed. If your application program performs a cold boot, AUTOEXEC will not be invoked.

Another special feature is FASTCOPY, a utility that will copy all files from one disk to another. It copies regardless of the user number, the system/directory flag, and the read/write status. FASTCOPY copies all files of all users, unlike PIP, which must be forced to read a system file or the file of another user and will not overwrite a read-only file. FASTCOPY uses the standard CP/M calls, so that if the extents in the source disk are

Function Number	Name of Function	Description
0	Set up serial ports	Sets all serial port parameters
1	Read character from port A	Reads data from and status of serial port A
2	Read character from port B	Reads data from and status of serial port B
3	Output character to port A	Outputs a character and returns status—serial port A
4	Output character to port B	Outputs a character and returns status—serial port B
5	Read serial port A status	Makes status of serial port A available
6	Read serial port B status	Makes status of serial port B available
7	Read Centronics port status	Reads status of hardware, Centronics parallel port
8	Send character to Centronics port	Bypasses CP/M input/output routines—parallel port
9	Set Centronics port options	Sets linefeed and formfeed options—parallel port
10	Set Centronics page length	Sets form length for software control—parallel port
11	Set Centronics printed lines per page	Sets number of lines before automatic linefeed—parallel port
12	Set Centronics top of page	Sets current physical line to top of page—parallel port
13	Set all drives to unknown density	Forces density determination at next disk access
14	Read real-time clock	Returns 4-byte tick count clock value
15	Read time-of-day clock	Returns time of day in 24-hour format
16	Set time-of-day clock	Resets current value of time-of-day clock
17	Read x-y of cursor	Returns current row and column of screen cursor
18	Read character at current cursor location	Reads character at row/column and bit 7 on if reverse video
19	Set size and blink of cursor	Sets 0 to 9 pixels high, off, nonflashing, slow or fast flash
20	Set cursor blink and on/off	Sets as above, without altering cursor size
21	Enable access to screen	Switches screen into Z80 address space
22	Disable access to screen	Switches normal memory back in
23	Set split screen mode	Protects top of screen from line 0 to 23
24	Read system date	Returns day of week, day of month, month, and year
25	Set system date	Resets current system date
26	Set console Control-C trap	Enables/disables break function filter in console handler

Table 3: *Special system calls offered in the Pickles & Trout version of CP/M. These functions can be called from within high-level languages.*

fragmented and scattered all over the disk, FASTCOPY will lay the copied file down sequentially on a clean disk. If you are copying to a partially full disk, some fragmentation may occur because FASTCOPY deletes the name of a destination file from the destination disk before writing the copy. Still, FASTCOPY is extremely useful in both single-drive and multiple-drive systems because it is so much more efficient than PIP for moving files.

TRS2CPM is handy for files and programs that run under TRSDOS. TRS2CPM allows you to move a file from a TRSDOS disk to a CP/M disk. It displays the files on the TRSDOS disk and allows you to choose the ones to move. If the file is a text file, you have the option of supplying a linefeed after each carriage return. If the file is an executable file, the load and execute addresses are displayed. If the file is a data file, the size is displayed.

For programmers writing application programs that access the BIOS, Pickles & Trout has provided complete implementation of the normal CP/M BIOS jump vector and included five additional BIOS calls. The additional calls support I/O to the serial ports and user I/O functions, with the addition of a supplemental user I/O device table.

Another feature I particularly like about Pickles & Trout CP/M is that it has a very good implementation of the Hold key, which can be used to start and stop execution and scrolling. You don't have to press a Control-S to stop scrolling or program execution, then press any key to resume, as with standard CP/Ms.

The area where Pickles & Trout really stands head and shoulders above all other Model II CP/Ms is special system calls. It has an interface at hexadecimal 40 on page 0 that is called in a manner similar to the BDOS entry point at hexadecimal 05. Parameters are passed to the special system calls for 26 functions in a manner similar to CP/M. The special system calls can be invoked at the assembly-language level or from a high-level language. I found it very easy to interface in BASIC and PL/I. The functions available are listed in table 3.

Conclusions

Pickles & Trout gives the information necessary for users of CP/M packages such as Magic Wand and Wordstar, which allow them to be used effectively. It also provides hexadecimal files and data files so beginners can set up these and other packages with a minimum of effort.

Pickles & Trout provides the kind of vendor support that everyone dreams of. The company's technical people can answer most questions immediately, and if you have a complex problem they will generally get back to you in short order with a solution or suggestion.

Pickles & Trout CP/M is indeed the Cadillac of Model II CP/Ms. It has all of the features that a serious Model II user looks for in addition to being well documented and supported. I have not found an application package that cannot run under it. We do indeed have a gourmet delight in Pickles & Trout CP/M.■

TRS-80 Disk Editor/Assemblers

T.A. Daneliuk
4927 North Rockwell
Chicago, IL 60625

Assembly-language programming is an exacting skill that can try the patience of even the best programmer. A good editor/assembler package can make this difficult and tedious procedure more efficient, but a poorly thought-out package can discourage the novice from ever really trying to learn assembly language. Presented here are two assembly-language packages implemented on the TRS-80 Models I and III. They differ substantially in price, but each offers features sure to appeal to particular programming tastes.

Series I Editor/Assembler

From the beginning, Radio Shack offered Disk Editor/Assembler, a moderately priced assembly-language package for the Model I, but it was restricted to saving source and object files on cassette. The user of the disk-based system was offered only the vastly more complex macro assembler. Then Radio Shack introduced the Model III, and unfortunately neither of these packages would work with the new computer. The Series I Editor/Assembler is Radio Shack's answer to these problems and is available for either the Model I or the Model III in disk or cassette version.

If you're familiar with the TRS-80 BASIC editor, you should be right at home with the Series I editor. The line-editing subcommands are virtually identical to those of BASIC. The editor also provides all the necessary commands to manipulate and display whole groups of lines. Lines of source code may be listed on the screen, deleted, printed, and renumbered. Also available are commands to insert new lines, load source files from disk, display memory status, replace lines, write source files to disk, and find a particular string of text within a group of lines. The latter command facilitates the editing of extremely long source files. The editor is easy to use, and the documentation is sprinkled with helpful examples. One rather nice feature of this editor is that it will automatically renumber the lines involved if a "line-collision" occurs; i.e., if you try to write a source statement to a line number that already exists, the lines will be renumbered to accommodate both the original line and the addition.

The Series I assembler appears to be a disk version of the older Model I cassette editor/assembler. All the Z80 mnemonics are supported and the following pseudo-operations are implemented: ORG, EQU, DEFL, END, DEFB, DEFW, DEFS, and DEFM.

The assembly itself is controlled by a set of "switches" that control the following: output of assembled code to the line printer, waiting on errors, creating a symbol table, and establishing whether to list the assembly to the

At a Glance

Name
Series I Editor/Assembler

Type
Assembly-language programming package

Format
5¼-inch disk

Manufacturer
Radio Shack
Division of Tandy Corp.
One Tandy Center
Fort Worth, TX 76102
(817) 390-3011

Price
$34.95 for disk, $29.95 for cassette

Language
Z80 machine-language

Computer
TRS-80 Model I or III with one disk drive or cassette recorder.

Documentation
255 pages in a 3-ring binder

Audience
Present and would-be assembly-language programmers

At a Glance

Name EDAS	**Language** Z80 machine-language
Type Assembly-language programming package	**Computer** TRS-80 Model I or III with one disk drive
Format 5¼-inch disk	**Documentation** Approximately 50 pages in a 3-ring binder
Manufacturer Misosys 5904 Edgehill Drive Alexandria, VA 22303 (703) 960-2998	**Audience** Present and would-be assembly-language programmers
Price $79.00	

screen and whether to output object code. The assembler also recognizes the LIST ON and LIST OFF commands to control the listing of the file during assembly. Finally, addition, subtraction, negation, logical AND, left shift, and right shift are all allowed in a source statement. Symbolic labels up to six alphanumeric characters in length are also allowed.

On the Model I, the disk version runs under TRSDOS 2.3B (supplied with the assembler) which is incompatible with the older TRSDOS 2.3. Provision is made to transfer files from the older TRSDOS to version 2.3B, but not to transfer files back to TRSDOS 2.3. Object code can be saved to the older DOS by using the DUMP command. Provision is also made to transfer source and object programs generated from the tape editor/assemblers to disk. The Model III version runs under TRSDOS 1.3.

The documentation of this package is very good, and the index is especially thorough and helpful. Included are many examples of the various editor/assembler commands, as well as in-depth discussions of each Z80 instruction. However, the documentation itself is not a tutorial in assembly-language programming, and novice assembly-language programmers will need supplemental study material.

EDAS

The EDAS editor/assembler is destined to become a real favorite with both the novice and the expert programmer. It offers tremendous power and ease of use, and has all the features of the Series I Editor/Assembler described above and many more.

When EDAS is first loaded three options are available that, to my knowledge, are not available in any other package. Memory size may be specified, as in BASIC, to protect high memory from EDAS. You may request a prompt at the end of each printed page; this option, important when using single-sheet-fed printers, causes EDAS to wait for your signal to resume printing. Finally, EDAS may be run under a job control language such as is used with LDOS. This permits complete "hands-off" assembly of source files.

As with the Series I package, EDAS has an editor that is almost identical to the Level II BASIC editor. But while the EDAS editor includes those features found in Series I, many capabilities have been added to make the EDAS version an extremely powerful editor. These include direct branching to a memory location to begin execution, globally changing an existing string of text to a new string of text, finding a specified string of characters, killing a file on a disk, moving a block of text from one location to another, displaying a directory of a drive while in EDAS, sending source code without line numbers to a printer, viewing a file on a disk without loading it into the text buffer, and altering the lines and page of the line printer listings. EDAS also supports labels up to 14 characters long.

The assembler itself also has all the features of Series I but adds many of its own. Using the assembly "switches," it is possible to assemble the code directly into memory and execute a program by means of the branch command. It is also possible to specify a switch that suppresses the object listing of DEFM, DEFB, and DEFW pseudo-operations, which makes the listings a little neater. Finally, a switch to generate a cross-reference file is provided. EDAS comes with a cross-reference utility which generates a listing of symbols used in the source program. This greatly aids the debugging and writing of documentation for long programs.

In addition to the arithmetic and logical operations described above for Series I, EDAS supports multiplication, division, modulo, logical OR, and logical XOR. The pseudo-operations have also been augmented with the following:

TITLE: to title listing pages
SUBTTL: for subtitles on the listings
PAGE: to force a new listing page
COM: to generate comment blocks in the listing
SPACE: to force line spacing in listings
ERR: to generate error messages during assembly
IF and ENDIF: to generate conditional assemblies

One other pseudo-operation of interest is *GET. This command allows source files to be called from the disks during assembly. In effect, *GET handles assembling of source files that are too long to reside in memory. In fact, it is possible to put nothing but *GET commands and an END statement into the text buffer and initiate assembly. This allows all the memory space available to be used as a huge symbol table.

In addition to the cross-reference utility, EDAS comes with a CMDFILE utility, a general-purpose tape-to-disk, disk-to-tape, and disk-to-disk transfer utility. Among its many features, CMDFILE has the ability to take multiple SYSTEM tapes and append them together to create one large system tape or disk /CMD file. Also included is a

tape-to-disk utility called TTD that allows transferring files created under Radio Shack's EDTASM or Microsoft's EDTASM+ to disk for manipulation by EDAS.

EDAS runs under TRSDOS 2.3 and LDOS. It does *not* work under NEWDOS 80. Misosys claims that the problem is in NEWDOS 80, which doesn't have a certain vector that is in TRSDOS 2.3 and LDOS. Consequently, EDAS cannot be patched to run under NEWDOS 80.

The documentation for EDAS is excellent, although it doesn't have the detailed discussion of the Z80 op codes that Series I has, and there is no index. However, there is a discussion of the technical aspects of the file formats of EDAS source and object files, as well as how to link to the debugger in the DOS. Each major command is presented with a description of its function and several examples of its use.

Conclusions

It is almost impossible to draw direct comparisons between the Series I and EDAS packages because they differ considerably in price and complexity. Instead, I intend to comment on each in terms of its own merits.

I found the Series I package to be somewhat disappointing. While it has all the essentials for programming in assembly language, it really doesn't exploit the features of a disk-based system as fully as it could. The inability to use DOS commands such as DIR and KILL from within the editor is particularly inconvenient. I also miss an in-memory assembly feature, which is a real time-saving tool. Nevertheless, when you consider the price, Series I is extremely attractive for the occasional user of assembly language. The documentation is excellent and the examples profuse. (However, users of the cassette-based system would do much better with Microsoft's EDTASM+, which supports macros and includes ZBUG, an excellent debugger. Best of all, the price is the same as that for the Series I cassette package.)

EDAS is rapidly becoming my favorite editor/assembler package. Although it does not support many advanced pseudo-operations and macro capabilities, it is nonetheless very powerful. It is very easy to use and, in my estimation, is the best choice for the beginning programmer who intends to seriously pursue assembly-language programming. The advanced programmer is by no means constrained by EDAS, however. With commands like *GET and the conditional assembly, even the largest source files can be handled easily. The in-memory assembly greatly assists the programmer, as does the ability to use the DOS commands from the editor environment. The utilities which come with EDAS are also very useful. CMDFILE is particularly valuable for a great variety of tasks. The documentation for EDAS is excellent, though a summary of Z80 operations as found in the Series I package would be helpful. ■

Getting the Most from Your TI Programmer

Robert L Patton Jr, 1713 Parkcrest Terrace, Arlington, TX 76012

[HEX]
Enter number.
[STO] [÷] 64 [=] [DEC]
Write result as the initial digits of the answer.
[HEX] [×] 64 [+/−] [+] [RCL] [=] [DEC]
Write result as the last 2 digits of the answer.
Note: You can use [SHF] 8 [+/−] in place of [÷] 64 and [SHF] 8 [=] in place of [×] 64.

Figure 1: *An algorithm for the TI Programmer which converts 7- or 8-digit hexadecimal integers to decimal numbers.*

[DEC]
Enter last 2 digits (press [+/−] if negative).
[STO]
Enter first $n-2$ digits (press [+/−] if negative).
[HEX] [×] 64 [+] [RCL] [=]
Note: You can use [SHF] 8 [=] in place of [×] 64.

Figure 2: *An algorithm which will convert a 9- or 10-digit decimal integer to a hexadecimal number on the TI Programmer. The decimal integer may be in the range from −2147483648 to 2147483647.*

[HEX]
Enter exponent.
If exponent is greater than 80 then [−] 80 [=] and remember that the final answer will be negative.
If current value is greater than 40 then [−] 40 [=] [+/−] (For IBM 360/370 format, use this entry line regardless of the displayed value.)
[DEC] [×] 1.20412 [=]
Note: If result is positive, the integer part is the base 10 exponent. Subtract from the result before continuing. If result is negative, the base 10 exponent is negative with a magnitude one greater than the integer part of the number displayed. Add the magnitude to the result before continuing.
[×] 3919 [−] 3404 [=] [STO]
[×] [K] [=] [+] 42 [÷] 98 [÷] [K] [=] [=]
[×] [RCL] [+] [RCL] [−] 20 [×] [RCL]
[÷] 40 [+] 1 [÷] [K] [=] [=] [×] [RCL] [+] 1 [×] [K] [=] [STO]
[HEX]
Enter the 6 hexadecimal fraction digits.
[DEC] [÷] 256 [K] [=] [=] [=] [×] [RCL] [=]
This is the mantissa of the answer.

Figure 3: *An algorithm which converts floating-point decimal numbers to hexadecimal numbers. It is assumed that the leftmost byte is the exponent, the three other bytes are the fraction, the high-order bit is the sign of the number, and the next to high-order bit is the sign of the exponent.*

One of Texas Instruments' most unusual pocket calculators is called the Programmer. It does instantaneous arithmetic and base conversions in hexadecimal, octal and decimal. It also does logical functions in hex or octal.

Although it is a very handy instrument, you may run into difficulties if you are working with 4-byte arithmetic on your computer. You will not be able to convert 8-digit hexadecimal numbers to decimal because they overflow. Trying to convert a floating-point representation to its decimal equivalent seems impossible.

A solution is available. The keystroke algorithms shown here will let you make the conversion with a minimum of effort. ■

Convert floating-point E8765432 to decimal.

[HEX]
E8 [−] 80 [=] → 68 (final answer will be negative)
[−] 40 [=] [+/−] → FFFFFFd8
[DEC] [×] 1.20412 [=] → −48.1648 (exponent will be −49) [+] 49
[×] 3919 [÷] 3404 [=] [STO] → .96155958
[×] [K] [=] [+] 42 [÷] 98 [÷] [K] [=] [=] → 2.2830733
[×] [RCL] [+] [RCL] [−] 20 [×] [RCL]
[÷] 40 [+] 1 [÷] [K] [=] [=] → 1.6803667
[×] [RCL] [+] 1 [×] [K] [=] [STO] → 6.8422664
[HEX] 765432
[DEC] [÷] 256 [K] [=] [=] [=] [×] [RCL] [=] → 3.1626475
Final answer is -3.16265×10^{-49} (to 6 digits).

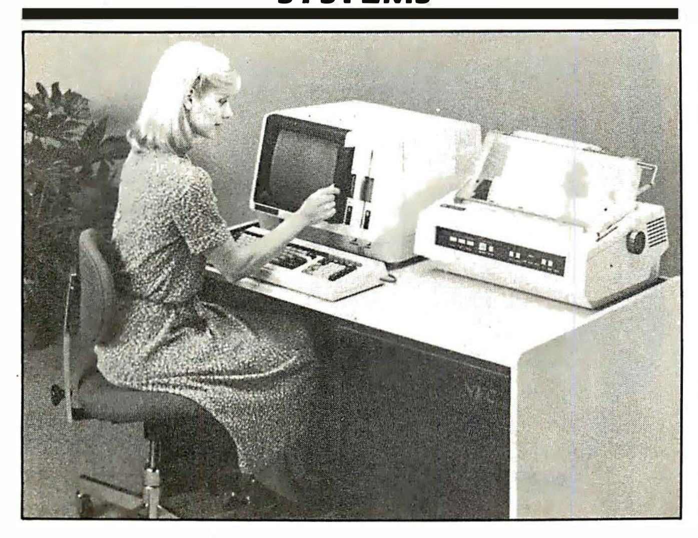
Figure 4: *An example showing use of the algorithm in figure 3.*

[SUM] [−] [RCL] [=] [SUM] [+/−]

Figure 5: *A short algorithm which will exchange the display and memory contents (provided the result does not cause overflow). This algorithm can be used with any memory calculator which has SUM and M+ keys.*



SYSTEMS

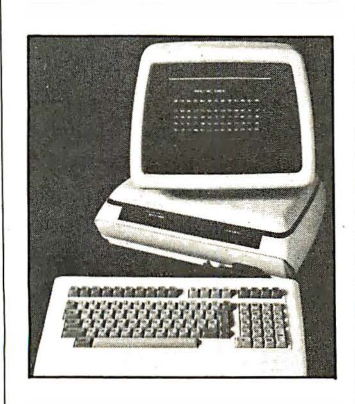


16-Bit Computer from NEC

NEC Information Systems' Advanced Personal Computer (APC) uses the CP/M-86 operating system and is based on a 16-bit NEC-manufactured 8086-compatible microprocessor. Features include 128K of user memory expandable to 256K bytes, color or monochrome displays, up to 2 megabytes of 8-inch double-sided double-density thin-line floppy-disk storage, detached keyboard with 22 user-definable dual-mode function keys, user-definable character sets, and high-resolution 8 by 19 dot-matrix characters.

A wide variety of software for the APC has been announced, including Microsoft's MS-DOS operating system, Accounting Plus from Systems Plus, the Benchmark word processor and Mailing List Manager from Metasoft, and Chang Laboratories' Microplan. Hardware options include the NEC 7220 processor for line-drawing graphics with a screen resolution of 640 by 475 pixels. The basic APC, which includes 128K bytes of RAM, one 8-inch drive, and a green-phosphor 80-character by 25-line 12-inch monitor, has a suggested retail price of $3298. Complete details are available from NEC Information Systems Inc., 5 Militia Dr., Lexington, MA 02173, (617) 862-3120.

Circle 600 on inquiry card.



Commodore Markets Business Computer Series

The B128 microcomputer is the vanguard of a new series of business computers from Commodore Business Machines. It offers 128K bytes of RAM (random-access read/write memory) and 40K bytes of ROM (read-only memory). The 6509-based B128 is equipped with a tilt-and-swivel 80-column by 25-line green-phosphor display, a built-in dual 5¼-inch disk drive, and a detachable 94-key keyboard with numeric keypad, double-zero and clear keys, a double-sized enter key, 10 function keys, and editing and cursor-control keys. Both RS-232C and IEEE-488 interfaces are built into the B128, which also comes with a real-time clock and a three-voice, nine-octave music synthesizer chip. Other standard features include the BASIC 4.0 language, output ports for direct connection to external sound systems, and a cartridge slot for plug-in software.

Among the expansion capabilities is the ability to accommodate a maximum of 256K bytes of internal RAM with as much as 640K bytes externally. Optionally, the B128 can be outfitted with a Z80 processor board to provide CP/M compatibility. In addition, CP/M-86 and UCSD Pascal are available. The B128 costs $1695. Further specifications are available from Commodore Business Machines Inc., Computer Systems Division, The Meadows, 487 Devon Park Dr., Wayne, PA 19087, (215) 687-9750.

Circle 601 on inquiry card.

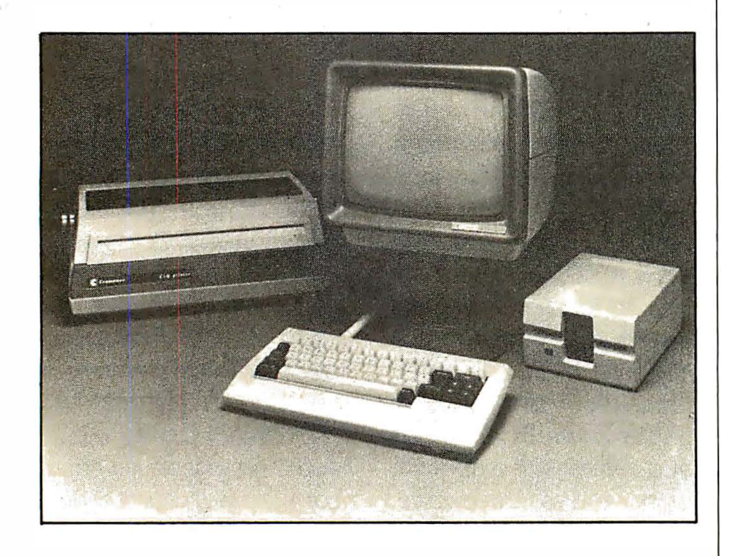


Sanyo Unveils Desktop Computer

The MBC-1000 desktop computer from Sanyo Business Systems Corporation uses an 8-bit Z80 microprocessor and comes with 64K bytes of RAM (random-access read/write memory). It features a green-phosphor, high-impact display screen and a detachable keyboard complete with number pad, cursor-control keys, and five programmable-function keys. Its single 5¼-inch double-sided double-density floppy-disk drive can be augmented with three more drives, or it can handle up to four 8-inch double-sided double-density drives for a total storage capacity of 5.2 megabytes. Standard software includes the CP/M operating system, Sanyo BASIC, diagnostics, and utilities. The MBC-1000 will support all CP/M-compatible software and will run CBASIC, MBASIC, FORTRAN, COBOL, and FORTH programs when equipped with the appropriate interpreter or compiler. Additionally, the MBC-1000 can be used in the Corvus Omninet network.

Software options include a word processor and elec-

tronic spreadsheets. A hard disk is also available. The MBC-1000 has a suggested list price of $1995. Further specifications can be obtained from Sanyo Business Systems Corp., Computer Division, 51 Joseph St., Moonachie, NJ 07074, (800) 526-7043; in New Jersey, (201) 440-9300.
Circle 602 on inquiry card.



Inexpensive Personal Computer from Cromemco

Cromemco's C-10 SP (Super Pak) personal computer is supplied with a 12-inch display, detachable keyboard, 5¼-inch disk drive with 390K bytes of storage, and three software packages. The C-10 SP features a 4-MHz Z80 microprocessor, 64K bytes of internal user-accessible RAM (random-access read/write memory), and 24K bytes of ROM (read-only memory). Its display produces 25 lines of 80 characters and has four character sets, including graphics, supplied in 4K bytes of ROM. Data communications capabilities consist of an RS-232C serial port, a parallel Centronics-type printer port, a serial printer interface, and the ability to emulate many different terminals and data protocols. Supplied software includes a CP/M-compatible operating system, a word-processing program, a financial spreadsheet calculator, and 32K bytes of structured BASIC.

The CP-10 SP costs $1785. Optionally, the CP-10 can be purchased without the disk drive and software for $995, or it can be obtained with a letter-quality printer, a tilt-and-swivel ergonomic stand, and the software for $2875. Full specifications are available from Cromemco Inc., 280 Bernardo Ave., Mountain View, CA 94043, (415) 964-7400.
Circle 603 on inquiry card.



Voyagers

Information Support Systems' Voyager II and III desktop microcomputers use 8085 microprocessors and have 64K bytes of RAM (random-access read/write memory). The Voyager II's dual floppy-disk drives provide 2 megabytes of storage, while a hard-disk subsystem gives the Voyager III 6 megabytes of storage. As CP/M-compatible systems, the Voyagers are supported by Information Support Systems' word processing, medical patient billing, and accounting packages. The accounting package features accounts payable and receivable, general ledger, inventory control, payroll and personnel, and job order-control capabilities.

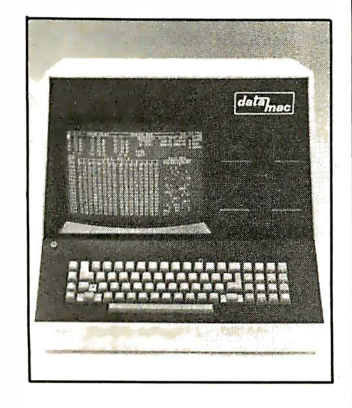
The suggested price for the Voyager II is $7745. The Voyager III costs $9990. Both systems are distributed by Hollander Office Products, Suite B, 41 Duesenberg Dr., Thousand Oaks, CA 91362, (800) 235-3524; in California, (805) 496-2533.
Circle 604 on inquiry card.

16-Bit Personal Computer from Hitachi

Hitachi's 16-bit 8088-based Personal Computer comes with 128K bytes of RAM (random-access read/write memory), expandable to 384K bytes. The system features a display screen, a detachable keyboard, a built-in double-sided double-density floppy-disk drive, and interfaces for other monitors, Centronics-type printers, light pens, and RS-232C communication devices. The screen can display 80 by 25 or 40 by 25 formats using 15 colors or in monochrome, and a large-capacity video RAM provides 640-dot horizontal by 400-dot vertical

graphics resolution in eight colors. The ability to overlay text and graphics is also supplied. The Hitachi Personal Computer runs under Microsoft's MS-DOS operating system and is supplied with a BASIC interpreter.

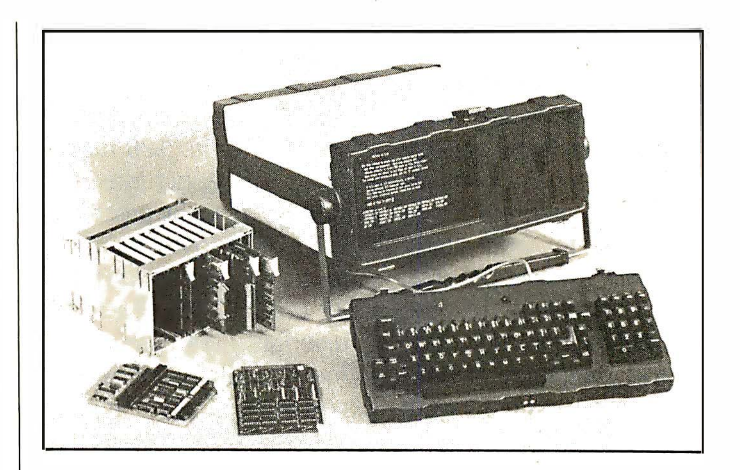
Optional equipment available for the Hitachi Personal Computer includes an 8087 mathematics processor and Pascal, FORTRAN, COBOL, and assembler languages. For marketing and pricing information, contact Hitachi Sales Corp., The Hitachi Atago Building #15-12, Nishi-Shimbashi 2-chome, Minato-ku, Tokyo 105, Japan; tel: Tokyo (03) 502-2111; Telex: J24492, J22391, J24114.
Circle 605 on inquiry card.



Low-Cost Desktop Systems

Datamac Computer Systems' 1200 Series of self-contained, portable desktop microcomputers are CP/M-compatible. Based on the Z80 processor, each system has 64K bytes of RAM (random-access read/write memory), two RS-232C ports, a parallel port, display screen, and one or two 5¼-inch floppy-disk drives. Drive formats can be single- or double-sided, single- or double-density, or 96 tracks per inch. The series features simultaneous use of hard disk and 5¼- and 8-inch floppy disks, local networking and multiuser capabilities, intelligent terminal emulation, RAM memory expansion up to 320K bytes, multiple-disk formats, and remote diagnostics. Also provided are 12 programmable-function keys, up to 58K bytes of user memory under CP/M, and a Help key capability. Options include an EPROM (erasable programmable read-only memory) burner and a System Activity Monitor that lets you display or alter memory and registers, set breakpoints, and single-step through a program as it runs.

The basic Datamac 1200, excluding disk drives but with a disk controller, costs $2650. The $4195 Datamac 1255 has two 5¼-inch double-sided double-density floppy-disk drives, each with 409K bytes of storage. The Datamac 1265, which has two 5¼-inch double-sided 96-track-per-inch drives each capable of storing 788K bytes of data, has a suggested list price of $4670. Full details on the 1200 Series are available from Datamac Computer Systems, 680 Almanor Ave., Sunnyvale, CA 94086, (408) 735-0323.
Circle 606 on inquiry card.



Portable Computer Handles Any Application

The M6000P portable computer lets users configure for virtually any application, according to Micro Source. The unit features 368K bytes of storage per 5¼-inch floppy-disk drive, a modular design using STD-bus boards with an 8-slot card cage that can be expanded to 12 slots, a 9-inch green-phosphor cathode-ray tube with an 80-character by 24-line display format, and a VT-100-style detachable keyboard. The M6000P uses the Z80 processor, but it's upgradable to 68000 operation by virtue of the STD bus. The M6000P can use single- and double-sided single- or double-density disks under the CP/M 2.2 operating system. A rear connector for an optional 8-inch disk drive is provided. Standard software includes the Superfile database manager and Micropro's Wordstar, Calcstar, Spellstar, and Mailmerge programs.

Optional equipment for the M6000P includes a 10-megabyte Winchester hard disk, battery backup, printer, an 8-inch floppy-disk drive, add-on memory cards, and a 6809 card running Flex. Prices start at $3900. Complete details are available from the Micro Source Inc., POB 319, New Lebanon, OH 45345, (513) 687-1395.
Circle 607 on inquiry card.

16-Bit Supermicros

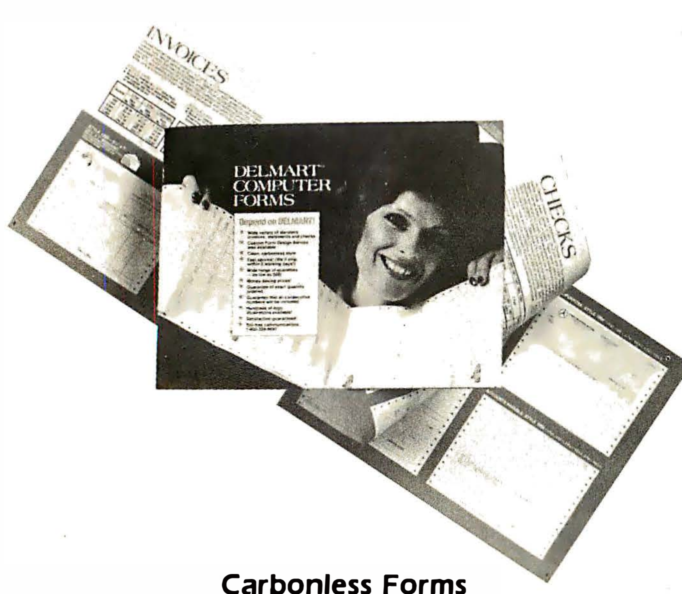
Molecular Computer now offers 16-bit processing power on its multiuser Supermicro 8 and Supermicro 32 systems. The 16-bit capability, which is based on the 8086 microprocessor from Intel with up to 1 megabyte of memory, will coexist in the same system with 8-bit Z80 processors running under the CP/M-compatible n/Star operating system. This arrangement lets each user have a dedicated 8-bit Z80 and 64K bytes of memory for CP/M-compatible applications, while the 16-bit CP/M-86-compatible capa-

bility gives all users a shared resource with more addressing space. The increase in addressing space means that large applications such as complex modeling, graphics, large spreadsheets, and statistical packages are possible. Other features of the 16-bit Supermicros include up to 1 megabyte of RAM (random-access read/write memory) in 256K-byte increments, an Intel 8089 I/O DMA (direct memory access) processor, an 8-MHz system clock, and parity for error detection.

Options include error correction circuitry, the 8087 mathematics processor, and up to 128 megabytes of Winchester-disk storage. A 16-bit processor with 256K bytes of RAM for both Supermicro 8 and 32 costs $2795. Each additional 256K-byte increment, up to 1 megabyte, costs $1495. For complete details, contact Molecular Computer, 1841 Zanker Rd., San Jose, CA 95112, (408) 995-5440.

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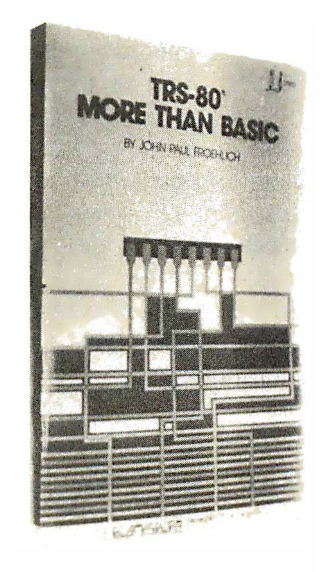
PUBLICATIONS



Carbonless Forms for Small Computers Detailed

A free eight-page color catalog detailing carbonless forms for small computers is available from the Delmart Company. The catalog presents a line of carbonless checks, invoices, and statements, plus a description of Delmart's custom-design service for variations in format, typefaces, and choice of different logos. Direct-mail prices for quantities as low as 500 are provided. Call or write Delmart Co., 530 North Wheeler St., POB 43495, St. Paul, MN 55164, (800) 328-9697; in Minnesota, call (612) 483-7888.

Circle 609 on inquiry card.



TRS-80: More Than BASIC

The most recent addition to the Blacksburg Continuing Education Series, TRS-80: More Than BASIC, by John Paul Froehlich, shows you how to convert your TRS-80 Model I or III into a development system for programming in Z80 instruction-code mnemonics. It shows you how to convert the TRS-80 by loading object code from cassette or floppy disk or by replacing the BASIC ROM (read-only memory). It explains how you can obtain written text useful in tracing system development, and descriptions of the hardware for programming EPROMs (erasable programmable read-only memories) are provided. Appendices in TRS-80: More than BASIC furnish the command sequence table, references, a list of hardware and software suppliers, and source-code listing for the monitor program and for programming 2708, 2716, and 8755 EPROMs.

Available in softcover, the 220-page TRS-80: More Than BASIC costs $10.95, plus $1 shipping and handling. Order yours from Group Technology Ltd., POB 87, Check, VA 24072, (703) 651-3153.

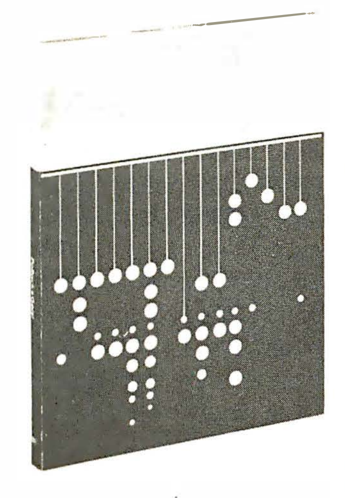
Circle 610 on inquiry card.

Logical Database Design Explained

Logical Data Base Design by Robert M. Curtice and Paul E. Jones has all the information you need to develop a realistic working knowledge of effective logical database design, according to the publisher. Logical database design is organized as a set of rules and techniques within the bounds of a single methodological framework. Numerous illustrations and detailed descriptions of the problems and choices designers must face lead you beyond elementary principles and provide insight into the real issues encountered during the design process. Curtice and Jones supply extensive examinations of data elements, including the taxonomy of data, examples of elements that you're most likely to face, and a real database. The analysis of user requirements is covered, as well as the identification of entities and their representations, and the sorting out of relationships among entities. Other topics addressed include procedures for checking and preserving the integrity of logical data structure,

how to document a logical design, notational conventions, how to use the notation, fundamental rules of logical database design, and guidelines for logical design.

Logical Data Base Design is available for $29.95 from Van Nostrand Reinhold, 135 West 50th St., New York, NY 10020, (212) 265-8700.
Circle 611 on inquiry card.



Structured COBOL Programming

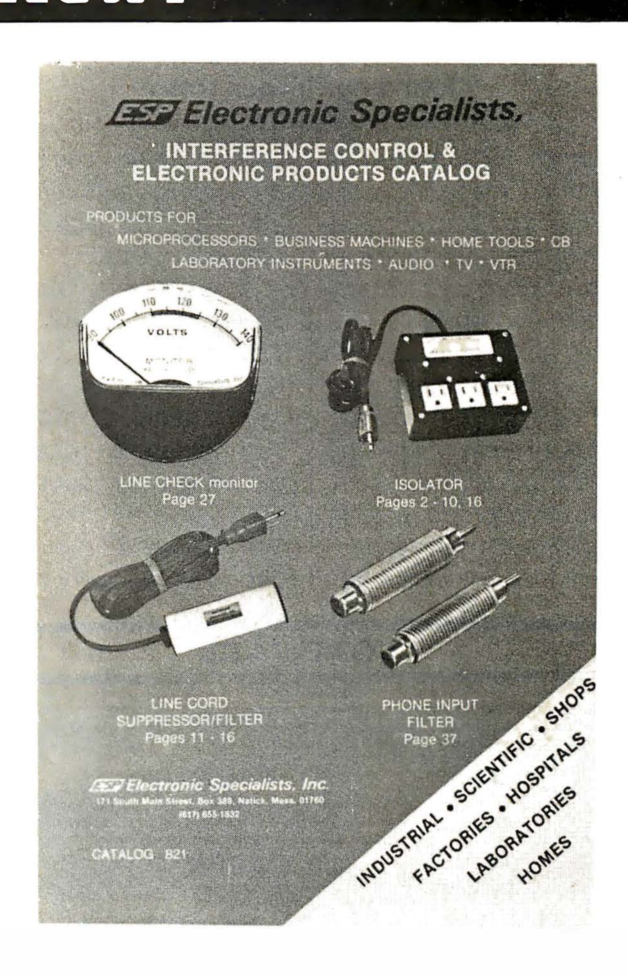
Structured COBOL Programming by Morris Pollack and Harry Geist can be used as a textbook in a one- or two-semester course or as a self-instruction guide. Its exercises provide you with practice in writing program segments, and its problems develop several programs, step-by-step, so that you can apply what you have learned in an orderly fashion. Each chapter is complemented by a concise outline of the concepts presented. Other features of **Structured COBOL Programming** include appendices covering keypunching, BIM OS JCL, COBOL reserved words, and the Environment Division. A glossary of COBOL and computing terms, a selected bibliography, and an index supplement the text.

Structured COBOL Programming has a suggested list price of $17.95. An accompanying instructor's guide costs $3.33. Contact Bobbs-Merrill Educational Publishing, 4300 West 62nd St., POB 7080, Indianapolis, IN 46206, (317) 298-5400.
Circle 612 on inquiry card.

Newsletter Focuses on TCS Accounting Software

Rocky Mountain Software Systems produces a quarterly newletter for users of the TCS (Technical Systems Consultants) accounting software sytem. **TCS Debits and Credits** has bug reports and fixes, potential enhancements to make the system more powerful or easier to use, new products and new version announcements, news on TCS-compatible products or services, and helpful ideas.

Subscriptions to **TCS Debits and Credits** are available to any TCS user for $20 a year. A low-cost floppy-disk update service is available to subscribers. Contact Rocky Mountain Software Systems, POB 3282, Walnut Creek, CA 94598, (415) 625-1592.
Circle 613 on inquiry card.



Electronic Products Catalog

Electronic Specialists has produced a 40-page catalog that presents its entire line of microcomputer interference-control cards. Also included are protective devices, line-voltage regulators, and AC power interrupters. Descriptive sections outlining particular problems and suggested solutions are provided, and typical applications and uses are highlighted.

Request catalog 821 from Electronic Specialists Inc., 171 South Main St., POB 389, Natick, MA 01760, (617) 655-1532.
Circle 614 on inquiry card.

Magazine for Heath/Zenith Users

Sextant is an independent magazine designed for Heath/Zenith users. Its articles cover a wide variety of topics, including color graphics applications, advice on choosing programming languages, analyses of H/Z89 interface hardware, software reviews, and game programs.

Annual subscriptions cost $9.97 (four issues). Contact **Sextant**, 716 E St. SE, Washington, DC 20003, (202) 544-0900.
Circle 615 on inquiry card.

What's New?

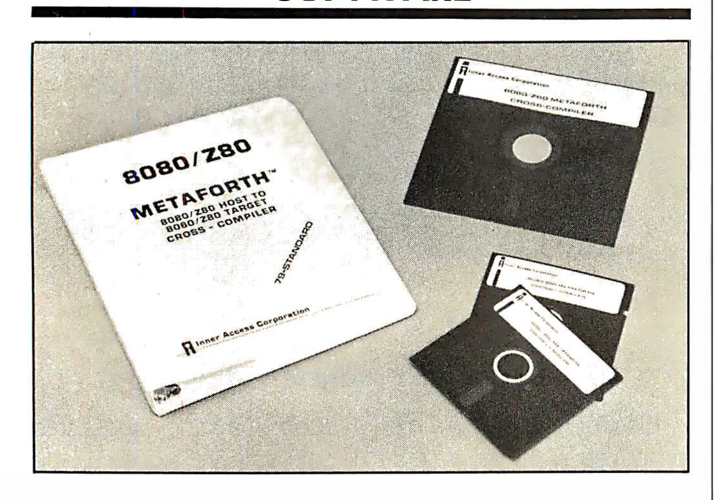
Quarterly Probes Voice Synthesis and Recognition

Speech Technology is a quarterly magazine devoted to the latest technical developments and applications in voice synthesis and speech recognition. Designed for engineers, scientists, educators, managers, and users, this journal probes all areas of speech-technology research from semiconductors to speech science. Other topics covered include digital signal processing, computer-processing architecture, and effective applications of human factors.

A year's subscription to Speech Technology costs $50 in the U.S., $58 in Canada and Mexico, and $67 elsewhere. Speech Technology is published by Media Dimensions Inc., 525 East 82nd St., New York, NY 10028.

Circle 616 on inquiry card.

SOFTWARE



FORTH CP/M and CDOS Cross-Compiler

Inner Access Corporation's 8080/Z80 MetaFORTH cross-compiler runs under CP/M or Cromemco's CDOS disk operating systems. MetaFORTH has both 8080 and Z80 assemblers and produces code that can be downloaded to any Z80- or 8080-based computer or put into ROM (read-only memory). It uses a built-in 79 Standard FORTH under CP/M or CDOS to create 79 FORTH code with an application on the target machine. Optionally, the target FORTH and application can be written without headers and link words for space savings on the order of 25% to 30%.

MetaFORTH requires an 8080- or Z80-based system with 48K bytes of memory and CP/M or CDOS. It's available on a single-sided single-density 8-inch IBM-format floppy disk and on two 5¼-inch CDOS-format disks. The price is $450. Contact Inner Access Corp., POB 888, Belmont, CA 94002, (415) 591-8295, for details.

Circle 617 on inquiry card.

Powertext for IBM

Beaman Porter's Powertext word-processing system for the IBM Personal Computer has sophisticated editing and comprehensive text-formatting capabilities. Automatic copy-placement styles include margins, indents, spacing, super- and subscripts, justification, centering, variable pitch, pagination, and table of contents. Complementing this are features such as form letters, automatic headers and footers, and unlimited documentation length. Other standard Powertext abilities include 132-character lines, vertical and horizontal border lines, boxed copy, print macro instructions, up to 14 columns, automatic footnote numbers, boiler-plate inclusion, and automatic title page, envelope, and labeling.

Powertext for the IBM Personal Computer is a run-time bootable system requiring a minimum of 64K bytes of memory, two disk drives, and a serial or parallel printer. It can accommodate 200K bytes per disk and, if your system has more than 64K bytes of memory, Powertext can provide extended memory for the program environment and RAM (random-access read/write memory) disk. Powertext costs $399, including disk and a manual. The manual alone is $25. Contact Beaman Porter Inc., Pleasant Ridge Rd., Harrison, NY 10528, (914) 967-3504.

Circle 618 on inquiry card.

H/Z89 Circuit-Analysis Program

Pressure Applications is marketing a circuit-analysis program for Heath/Zenith 89 computers. The program features steady-state circuit analysis of R-L-C elements, bipolar and junction FET transistors, and operational amplifiers. Its easy-to-use format and extensive function keys allow data files to be loaded and saved from disk. Also provided are element addition or deletion and listing to a printer functions.

The program, available for 5¼-inch hard-sectored disk only, requires the CP/M 2.2 operating system, MBASIC, and a minimum of 48K bytes of memory. It costs $30. A version with screen-plotting capabilities sells for $40. Order from Pressure Applications, 2478 Briarwood Dr., San Jose, CA 95125, (408) 269-6107.

Circle 619 on inquiry card.

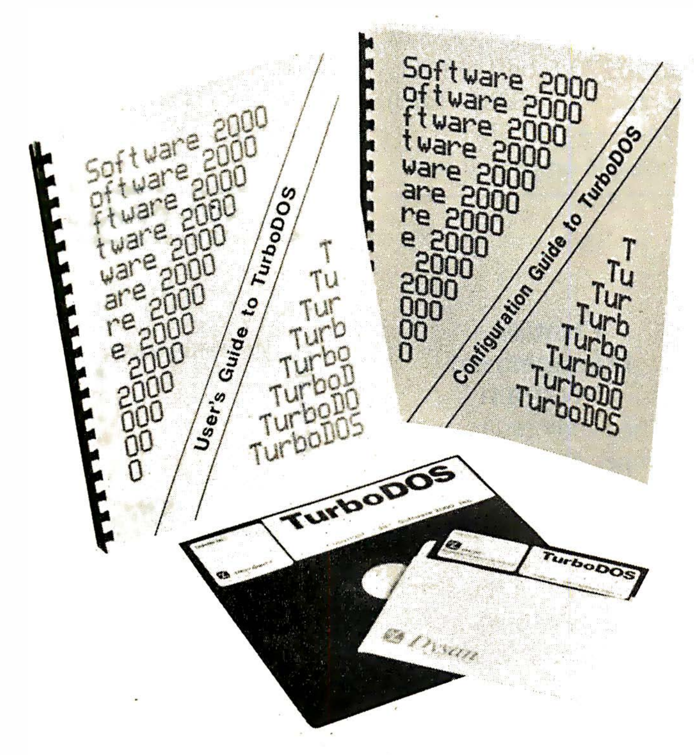
Visischedule for the Apple III

Visicorp has released a more powerful version of its Visischedule interactive project-management program for the Apple III computer. The number of tasks that can be performed with this Visischedule are nearly double that of the Apple II version because of the Apple III's larger internal memory. A 128K-byte Apple III will support from 145 to 215 tasks per project, and a 256K-byte

Apple III will handle 300 tasks.

A minimum of 128K bytes of memory and an external disk drive are required. A printer is recommended. The suggested retail price is $300. Contact Visicorp, 2895 Zanker Rd., San Jose, CA 95134, (408) 946-9000.

Circle 620 on inquiry card.



CP/M Applications Run Faster Under TurboDOS

TurboDOS, a Z80-based operating system, is a Software 2000 product said to be fully compatible with the CP/M 2.2 operating system, but three times as fast and capable of storing 25% to 35% more data on each disk. Available for single-user and networking configurations, TurboDOS supports hard disks to 1000 megabytes and features automatic file and record interlocks, high-performance print spooling, the ability to handle as many as 16 printers simultaneously, multiple commands per line, and nesting of command files.

Software 2000 has designed versions of TurboDOS for the TRS-80 Model II, Xerox 820, Televideo TS-800, Digilog 1000 and 1500, IMS International 5000 and 8000 series, and most S-100 bus systems. An adaptable version for any Z80-based microcomputer can be obtained. Complete TurboDOS specifications will be furnished by Software 2000 Inc., 1127 Hetrick Ave., Arroyo Grande, CA 93420, (805) 489-1977.

Circle 621 on inquiry card.

Flexible Programmer Tool

Digital Research's Access Manager programmer tool gives you a common method of data-access management for data files. Basically a general-purpose "keyed" file-access method, Access Manager lets you use meaningful key values, such as account number or customer name, to directly access data records on disk files. Indexes can be created to provide multiple keys to end-user files. It provides a common access method to the database, regardless of which Digital Research compiler language you are using, through its link to the run-time system of application programs running under the CP/M or MP/M II operating system. Data will be accessible through programs incorporating Access Manager and written in PL/I-80, Pascal/MT+, or the CBASIC compiler, CB-80.

Access Manager has a suggested single-user price of $300. Contact Digital Research, 160 Central Ave., Pacific Grove, CA 93950, (408) 649-3896, for full details.

Circle 622 on inquiry card.

Easy-to-Use Real Estate Software

Simple Soft's Quikcalc Real Estate Investor is designed for prospective homeowners, real estate brokers, and investors. It has four separate files that can help evaluate potential real estate sales or purchases. Basically a template for 64K-byte microcomputers using either Visicalc or Supercalc, Quikcalc is provided with separate models for individual residences and for income properties. Both models analyze purchase price, financing structure, tax implications, cash flow, and profitability after sale. All analyses are summarized into an inclusive internal rate of return.

Quikcalc has a suggested retail price of $129.95. Versions are available for most popular computers, including the Apple and the IBM Personal Computer. Address inquiries to Simple Soft Inc., Suite 101, 480 Eagle Dr., Elk Grove, IL 60007, (312) 364-0752.

Circle 623 on inquiry card.

Milestone

Milestone is a project-management and time-scheduling program from Digital Marketing. It's written in Pascal and runs on CP/M, UCSD, and Apple Pascal systems. For CP/M systems, it is compiled using Pascal/M and is delivered, ready-to-run, with the Pascal/M run-time package. For UCSD Pascal systems, Milestone comes as an executable p-code file. Milestone will run on an 8086-based machine with CP/M-86, a Z80 system with Cromemco's CDOS operating system, an Apple II running Apple

Pascal or equipped with a Z80 softcard, a TRS-80 Model II running CP/M, and a Z80-, 8080-, or 8085-based machine running CP/M. Additional requirements include 56K bytes of RAM (random-access read/write memory), one disk drive, an 80-column printer, and a terminal with a 24-line by 80-column display, absolute cursor positioning, and a home-and-clear function.

Complete specifications are available from Digital Marketing, 2670 Cherry Lane, Walnut Creek, CA 94596, (415) 938-2880.

Circle 624 on inquiry card.

CBASIC-2 Screen Handler

Screenmaster from Marketing Essentials is a CBASIC-2 module in source-code form for inclusion in CBASIC-2 programs requiring screen input with automatic validation. CBASIC-2 code can be inserted to affect any degree of editing and control, overriding Screenmaster if necessary. Screenmaster provides such commands as GOTO (field) n, BACKWARD and FORWARD n fields, NEXT and PRIOR (screen), as well as SUBMIT and ABORT. Its output is an in-memory array of user responses for further use by the programmer. The Screenmaster disk includes utilities to test and create screens. Screenmaster can be used with any dumb terminal.

Screenmaster is distributed on an 8-inch single-density CP/M-format disk; other formats are available. It costs $195, the manual alone is $25, and a demonstration disk can be purchased for $10. Order Screenmaster from Marketing Essentials Inc., 206 Mosher Ave., Woodmere, NY 11598, (800) 645-2622; in New York, (516) 569-4533.

Circle 625 on inquiry card.

Legend Slide Select

Legend Industries designed the Slide Select Program for use with its 64KC and 128KDE memory cards and the Apple II computer. The program, a combination of two pieces of software, lets you rapidly retrieve a high-resolution picture. One part of Slide Select is an Applesoft program that gives you control of high-resolution pictures. For the BASIC programmer, a machine-language interface is available for easy access to the Legend cards. Slide Select lets you flip back and forth between high-resolution pictures, resulting in the functional equivalent of a slide projector. Control over displayed pictures is user-selectable by means of the keyboard or game paddles, or it can be set to run automatically. Up to eight pictures can be stored in a 64KC card, and the 128KDE can store twice as much.

Slide Select comes standard when you purchase Legend 64KC or 128KDE memory cards, which cost $349 and $650, respectively. The program is also available as an $8 update for users who already have Legend cards. Contact your local Apple dealer or Legend Industries Ltd., 2220 Scott Lake Rd., Pontiac, MI 48054, (313) 674-0953.

Circle 626 on inquiry card.

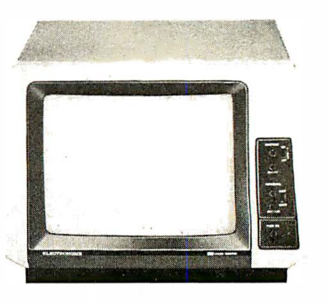
Citation-Management Program

The maintenance of your personal reference file of scientific and academic citations from journals, books, and conference proceedings can be simplified with Bibliotek version 2.0 from Scientific Software Products. Bibliotek automates the process of bibliography management from citation entry through printing a finished reference list. Citation entry, modification, deletion, searching, sorting, and printing are controlled through prompted keyboard entries. Searches can be made by keyword, source title, author and editor, title phrases, and date in any combination. Equipped with extensive facilities for editing and altering responses, Bibliotek can store approximately 500 references in a single bibliography, which consists of two disks.

Bibliotek version 2.0 requires an Apple II computer with 48K bytes of RAM (random-access read/write memory), Applesoft BASIC, two disk drives, and a printer. A single-user license costs $300, including an extensive reference manual. The manual alone is $25. Full details are available from Scientific Software Products Inc., 3171 Donald Ave., Indianapolis, IN 46224, (317) 299-0467.

Circle 627 on inquiry card.

PERIPHERALS

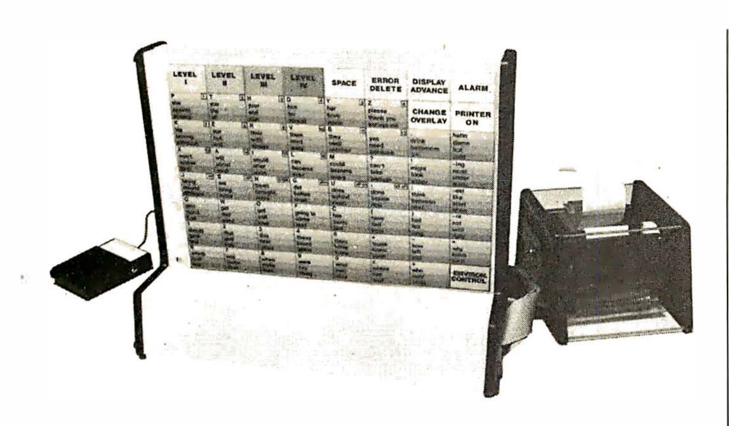


Color Display

The ECM-1301 from Electrohome Limited is a 13-inch general-purpose color display monitor. The ECM-1301 has six user controls and is directly compatible with the IBM Personal Computer. The ECM-1301 provides a broad bandwidth, and it has separate modules for connection to other computers, including 8- and 16-color modules and an RS-170 module for separate red-green-blue inputs.

The EMC-1301 comes in both medium- (580 by 235 pixels) and high-resolution (720 by 512 pixels) versions. It is FCC Class A approved. For details, contact Electrohome Ltd., 809 Wellington St. N, Kitchener, Ontario N2G 4J6, Canada.

Circle 628 on inquiry card.



Portable Communications System for the Disabled

Omni is a portable communications system for nonvocal, vocally impaired, or dexterity impaired individuals from Communications Research Corporation. A complete Omni system includes a display board, an LCD (liquid-crystal display) readout, hard-copy printout facility, 16K bytes of programmable memory, a remote environment control, audible alarm, typewriter interface, and computer access. With the Omni system, disabled individuals can switch lights and electrical equipment on and off, summon an attendant, and select messages in the form of printed words, phrases, symbols, or pictures. Omni is equipped with an RS-232C port that provides interface capabilities with computers. The system also can substitute for the computer's keyboard, which provides access to programming and data input. Its reader/printer attachment provides alphabetic interpretation of symbols or pictures.

The Omni System ranges in price from $1275 to $2975. For a brochure detailing optional equipment and ordering information, contact Communications Research Corp., 1720 130th Ave. NE, Bellevue, WA 98005, (800) 426-8075; in Alaska, Hawaii, and Washington, call (206) 881-9550.

Circle 629 on inquiry card.

VIC Timesharing with Printout

RVR Systems' MDM-1 is a modem driver module that plugs directly into the user port of the Commodore VIC-20. It's supplied with two serial ports for a modem and a printer and a terminal program that permits telephone line connections to large timesharing computers and computer networks, such as Dow Jones, The Source, and Compuserve. Additionally, the MDM-1 has two indicators that show transmissions to and from the VIC. All transmissions are simultaneously recorded on the VIC's screen and the serial printer. An external power source is not required.

The MDM-1 is available for $59, plus $3 shipping. For details, contact RVR Systems, POB 265, Dewitt, NY 13214.

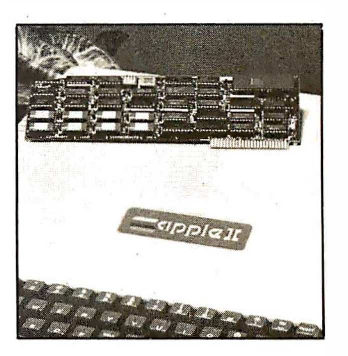
Circle 630 on inquiry card.

Intelligent Interface

Warn Electronics' intelligent printer interface for use with daisy-wheel printers, such as Hy-type I and Qume, lets you download data from the computer in either serial or parallel form. The interface, which uses a Z80 processor, relieves the host computer from controlling the printer so that it can perform more useful tasks. Data is stored in a software FIFO (first-in/first-out) buffer, using a space-compression technique. Data input can be accomplished by either a Centronics-compatible parallel port or a simplified RS-232C port (transmit data and receive data only). The parallel input has a variety of handshaking signals, including busy, printer fault, paper out, and ribbon out. Standard features include 16K bytes of storage, switch-selectable serial port data rates from 50 bps (bits per second) to 19,200 bps in 16 common rates, and selectable stop bits and parity.

The intelligent printer interface is available in an assembled and tested version or as a bare board and operating software. Both versions can be obtained with software allowing basic features such as a full 16K-byte buffer, setting of form length, and reprinting of buffer. Cabinets, front panels, cables, and a variety of PROMs (programmable read-only memories) are available. The price for the intelligent interface ranges from $125 to $525. Contact Warn Electronics Ltd., POB 526, Knightdale, NC 27545, (919) 266-9411.

Circle 631 on inquiry card.



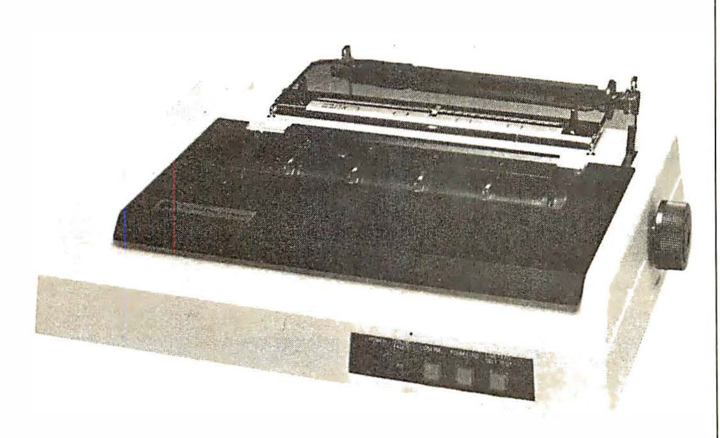
Run IBM Programs on the Apple II

The 88Card from Coprocessors lets Apple II owners run programs designed for the IBM Personal Computer. The card contains a 5-MHz 16-bit Intel 8088 processor, 64K bytes of RAM (random-access read/write memory), and control functions. Users merely plug the card into a vacant slot in the Apple, turning it into a 16-bit personal computer with 128K bytes of memory. The card is fully compatible with Apple peripherals such as printers and disk drives. The 88Card has the ability to switch between normal Apple programs and IBM programs, using the IBM's

operating system. It operates from the Apple's internal power supply.

The 88Card costs $899, including documentation. Further information is available from Coprocessors Inc., Suite 64, 50 West Brokaw Rd., San Jose, CA 95110, (408) 947-4616.

Circle 632 on inquiry card.

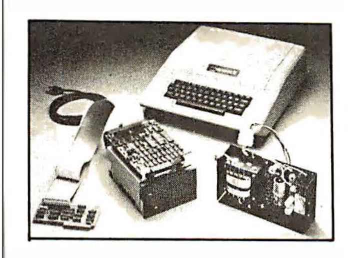


Low-Cost Printer Has Expensive Features

Integral Data Systems' Microprism produces fully-formed characters at 75 cps (characters per second) in a single pass of the print head. Standard features include a data mode for high-speed printouts at 110 cps, programmable character densities, an enhanced type mode, proportional and fixed spacing, automatic text justification, backspace and overstrike capabilities, and vertical and horizontal tabbing. Operator controls incorporate a fault and paper-out indicator and switches for power-up parameters, parallel or serial interfaces, and Xon/Xoff protocols. Dot-graphics features include 84 by 84 dots per inch resolution in a single pass, the ability to generate charts and drawings, and bit-mapped architecture for control over the output.

Microprism is compatible with other Prism series printers. It has a suggested retail price of $799 and can be ordered from Integral Data Systems, Milford, NH 03055, (603) 673-9100.

Circle 633 on inquiry card.



Apple II Hard-Disk Kit

A 5-megabyte Winchester hard-disk system kit for the Apple II computer is available from Xebec. According to the manufacturer, the kit can be assembled in less than 10 minutes and does not require technical expertise. The kit consists of a 5¼-inch 5-megabyte Winchester-disk drive and Xebec's S-1410 intelligent disk controller. Standard features include up to 22-bit error detection, up to 11-bit error correction, a full-sector data buffer, and single-command disk initialization. Supplied with the system is an Apple II Host Adapter Personality Card that supports Apple DOS (disk operating system), the CP/M operating system, and the Pascal language; a 115/230-volt power module; cable set; cabinet; DOS or CP/M software; and installation instructions and documentation.

The 5-megabyte hard-disk system for the Apple II costs $1299. Individual components can be purchased separately. Full specifications are available from Xebec, 432 Lakeside Dr., Sunnyvale, CA 94086, (800) 538-1644; in California, (800) 627-1842.

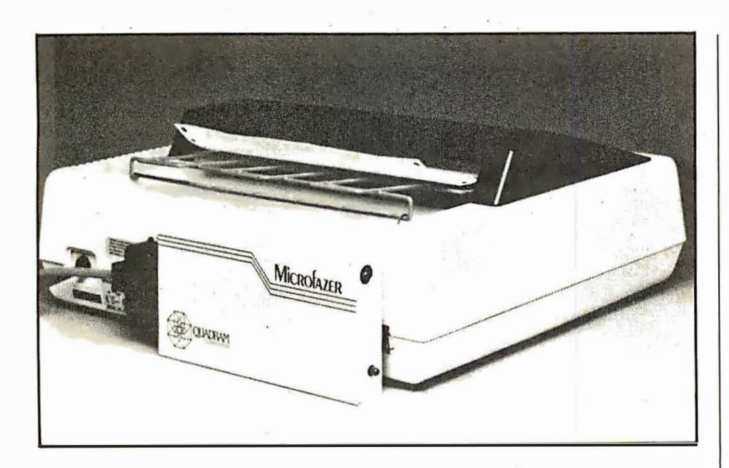
Circle 634 on inquiry card.

Omega 99G Printer from MPI

Micro Peripherals' Model 99G Omega is a bidirectional impact matrix printer. It can print on letterhead, bond paper, or multipart-cut forms because it has both a front-load, single-sheet feeder and a standard sprocket feed. With a maximum speed of 100 characters per second, the 99G can format printouts in 80-, 96-, or 136-column lines using a 7 by 9 dot matrix. High-quality printouts can be produced using an 11 by 9 matrix and a serif-style type font in an 80-column format. Double-wide characters are software-selectable from any of four print selections and can be intermixed on a line for message highlighting. Standard print features include full uppercase and lowercase ASCII (American Standard Code for Information Interchange) set, adjustable tractors for paper widths of 1 to 9 inches, 16 selectable forms lengths, skip-over perforation, user-selectable line spacing of 6 to 8 lines per inch, and a dot-addressable high-resolution graphics capability for plotting, printing of screen graphics, and generating special fonts, illustrations, and characters. Other standard features include a Centronics-type parallel interface, an RS-232C serial interface with Busy handshake and data rates ranging from 110 to 1200 bits per second, a 1K-byte buffer, and a continuous-loop ribbon cartridge.

A variety of options are available for the 99G, including a 2K-byte buffer, an IEEE-488 bus interface, and a 20-mA current loop. The 99G has a suggested retail price of $849. Details can be obtained from Micro Peripherals Inc., 4426 South Century Dr., Salt Lake City, UT 84107, (801) 263-3081.

Circle 635 on inquiry card.



Universal Printer Buffer

Microfazer from Quadram Corporation is a universal printer buffer that can be used with most popular microcomputers and parallel printers. It uses standard Centronics signals and can draw its power from most printers. Data is received from the computer at rates of up to 4000 characters per second, and Microfazer is user-expandable from 8K bytes to 64K bytes using standard 64K-byte 200-nanosecond chips. It's designed to attach directly to the input port of Epson and similar printers.

Microfazer is available in four models that offer buffering of 8K, 16K, 32K, and 64K bytes. Prices range from $159 to $299. Separate voltage power supplies are available where necessary. For complete details, contact Quadram Corp., 4357 Park Dr., Norcross, GA 30093, (404) 923-6666.

Circle 636 on inquiry card.

MISCELLANEOUS

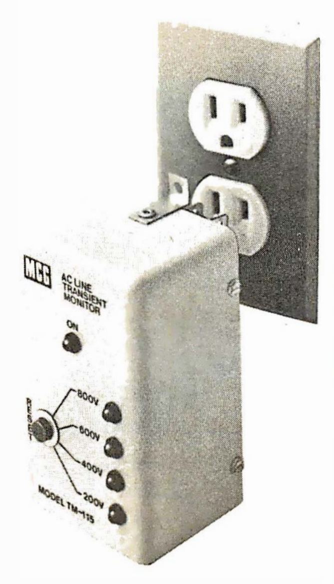
Allenbach to Market OEM-quality Disks

Allenbach Industries, best known for its high-quality disk-duplication service, has set up a dealer network for its line of blank OEM- (original equipment manufacturer) quality floppy disks. Previously available only to software producers, the 5¼- and 8-inch disks can be purchased in single- or double-sided formats and double-density.

When Allenbach duplicates your software, each disk is copied and verified bit-by-bit. Guaranteed to exceed ANSI (American National Standards Institute), ECMA (European Computer Manufacturers Association), and ISO (International Standards Organization) standards, Allenbach disks and duplication services carry lifetime warranties.

For complete details on the disks and disk-duplication services, contact Allenbach Industries, Suite A, 2101 Las Palmas, Carlsbad, CA 92008.

Circle 637 on inquiry card.



Plug-In Power-Line Monitor

MCG Electronics' AC Line Transient Monitor will determine whether your AC line power contains transients and surges that could cause your computer to lose data or garble information. The Monitor has five LEDs (light-emitting diodes) that indicate power-on and that the line current has reached 200, 400, 600, and 800 volts or more. Also provided is a memory feature that retains transient data for 24 hours, even if the Monitor has been accidentally unplugged.

The Monitor fits into any standard 120-volt AC outlet and can be moved from outlet to outlet so that you can determine which is best. The Monitor is also helpful in determining whether a newly installed machine will cause damage before it has a chance to do so. The AC Line Transient Monitor costs $189 and is available from MCG Electronics Corp., 160 Brook Ave., Deer Park, NY 11729, (516) 586-5125.

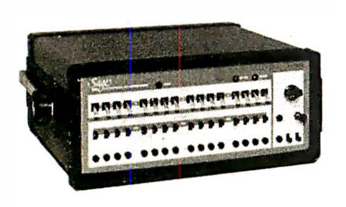
Circle 638 on inquiry card.

New Products from MPC

Apple II users can burn EPROMs (erasable programmable read-only memories) with MPC Peripherals Corporation's PROM-It EDS (EPROM Development System). The device can program 8K-, 16K-, and 32K-byte EPROMs such as the 2508, 2516, 2532, 2716, and 2732 with the change of a personality module. Its disk-based software helps you manipulate blocks, disk files, and EPROM code. Downloading hexadecimal files from any computer that's equipped with an RS-232C port is possible. Memory-mapped space permits execution of EPROM routines directly from PROM-It by means of the Apple's 6502 micrprocessor. A switch-selectable write-protect feature ensures EPROM-code stability. PROM-It costs $129.50.

Also available for the Apple II is an asynchronous serial I/O interface card, known as AP-SIO. It has driver firmware that follows the Apple's peripheral card convention, which ensures compatibility with all present and future operating systems. Switch-selectable firmware options include automatic linefeed/no linefeed, strip incoming linefeeds, half- and full-duplex, lower-

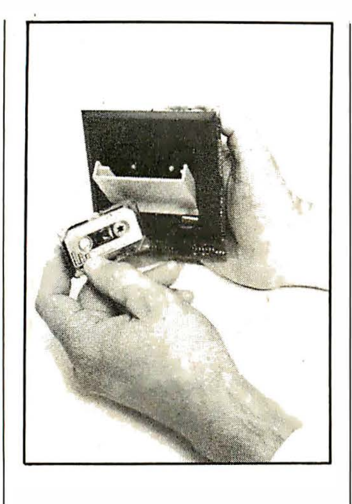
case-to-uppercase conversion/no conversion, and crystal-controlled data rates from 50 to 19,200 bits per second. The AP-SIO costs $129.50. For further specifications on these products, contact MPC Peripherals Corp., 9424 Chesapeake Dr., San Diego, CA 92123, (714) 278-0630.
Circle 639 on inquiry card.



High-Performance Logic Analyzer

Sage Enterprises' Model PI 1160 Logic Analyzer is a high-performance device designed for digital system testing and development. Tne 1160, nicknamed the Owl, is a 16-channel, 10-MHz logic analyzer that can be used with a standard dual-channel oscilloscope to obtain a 16-channel timing diagram display. When connected to a microcomputer, such as the Apple II, the Owl can provide video displays of timing diagrams, state tables in user-selectable binary, octal, or hexadecimal formats, and, with its Vector Graphic mode, an X,Y picture of digital information on the 16 channels.

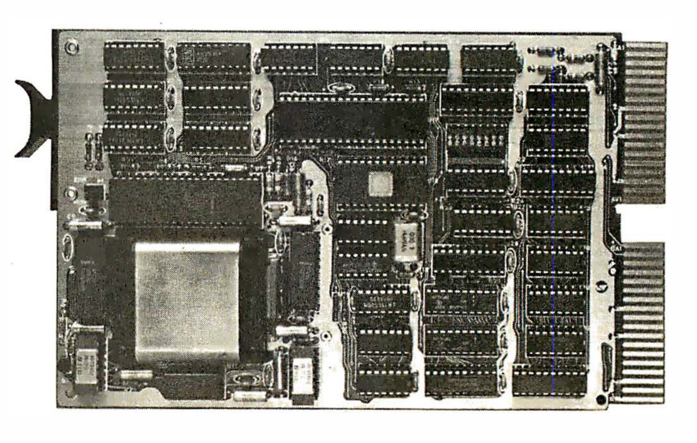
The Owl costs $950. For additional details, contact Sage Enterprises Inc., 1080 Linda Vista Ave., Mountain View, CA 94043, (415) 969-5111.
Circle 640 on inquiry card.



Minicassette Encode/Decode Circuit

Braemar Computer Devices is marketing an optional encode/decode circuit for its CM-600 Mini-Dek cassette drive. The data encode/decode capability eliminates the need for host hardware or software features to provide data timing and verification. Integral encoding/decoding also does away with costly engineering time that's required to interface the CM-600 to various digital applications.

The CM-600 uses minicassettes to record up to 90K bytes of data on a 50-foot cassette at a standard rate of 2400 bits per second. Power requirements are 1 watt at 5 volts DC. The encode/decode option adds $25 to the CM-600's $100 price tag. Complete details are available from Braemar Computer Devices, 11950 12th Ave. S, Burnsville, MN 55337, (612) 890-5135.
Circle 641 on inquiry card.



Bubble Memory for LSI-11

Bubbl-Tec is marketing a single-board magnetic-bubble mass-storage memory system for DEC (Digital Equipment Corporation) LSI-11 computers. The QSB-11 Bubbl-Board is made up of a 1-megabit bubble device and a controller that emulates DEC's RX01 floppy-disk system. The controller handles bubble-device formatting and control, interfaces the bubble-memory system to the LSI's bus structure, and provides both soft- and hard-error protection and correction. Built on a dual-height LSI-11 module, the QSB-11 has 128K bytes of nonvolatile storage, an average access time to first data byte of less than 41 milliseconds, and data-transfer rates exceeding 68,000 bits per second. Power consumption is less than 15 watts, and only +5-volt and +12-volt power is required, both of which come directly from the LSI-11 bus.

The QSB-11 Bubbl-Board is fully compatible with all DEC LSI-11 systems, including the LSI-11/02 and -11/23, the SBC-11/21 Falcon, and the LSI-11/23 Plus. The price is $1614, quantity ten; OEM (original equipment manufacturer) discounts are available. Contact Bubbl-Tec, 6800 Sierra Court, Dublin, CA 94566, (415) 829-8700.
Circle 642 on inquiry card.

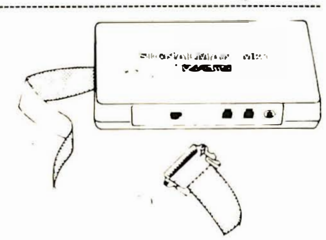
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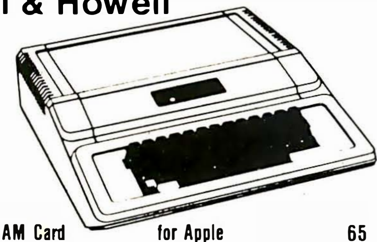
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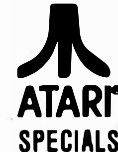
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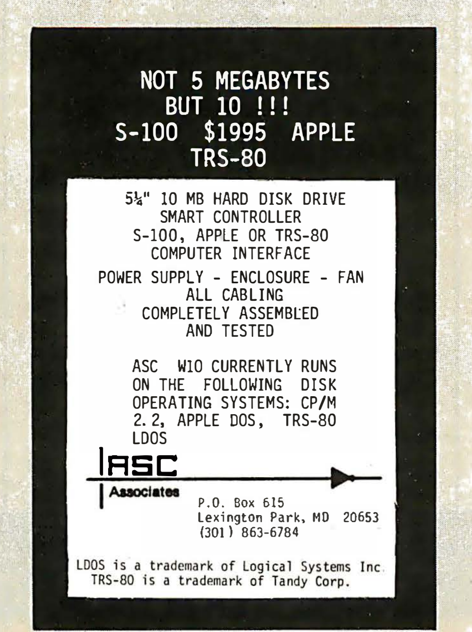
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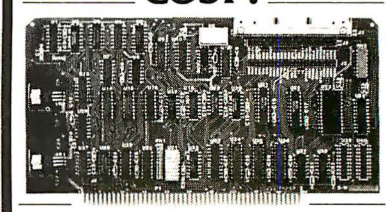
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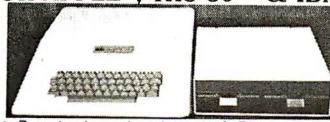


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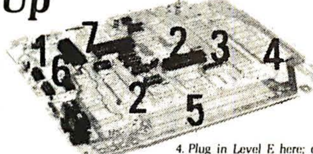
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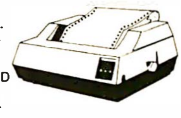
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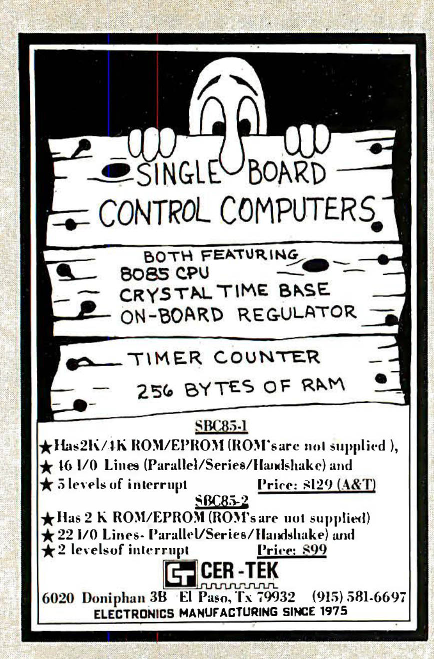
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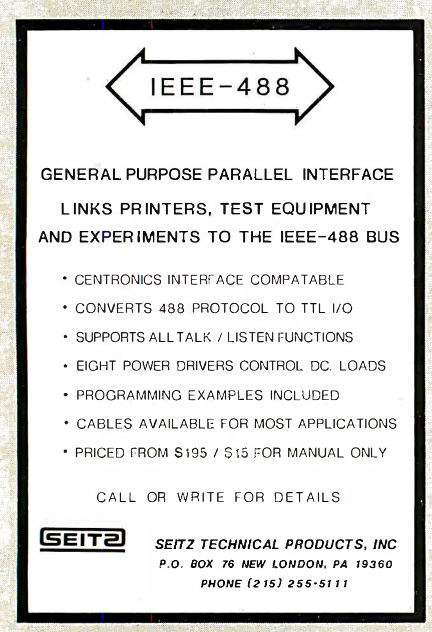
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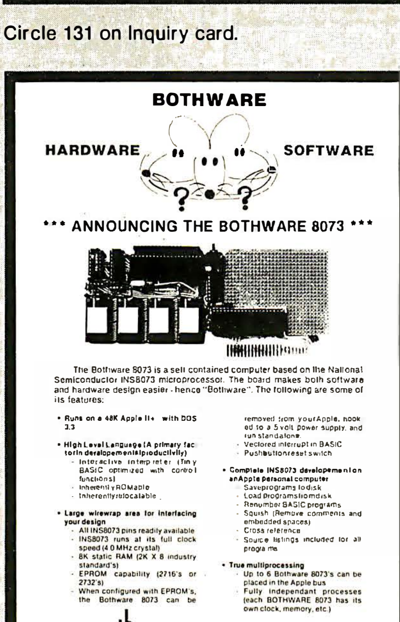
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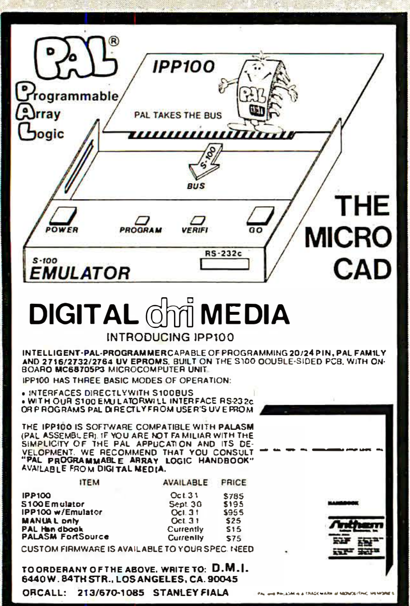
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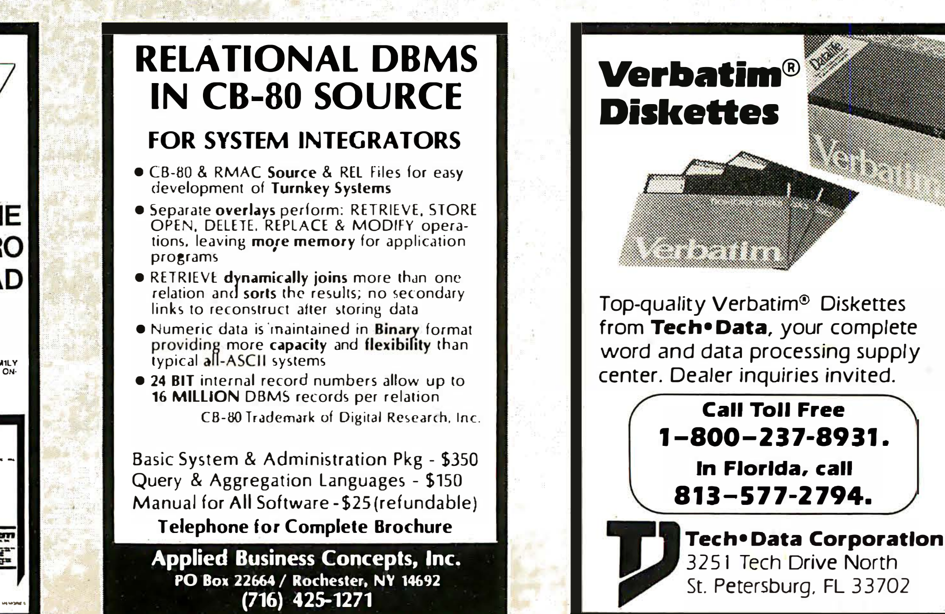
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VENTURE is a 16" by 20" main board with separate ASCII and HEX keyboards. It runs fast, almost 4 MHz, and has the capability of putting almost 1 megabyte of RAM and ROM on the board along with a variety of inexpensive options.

A 16-channel analog-to-digital converter allows use of joysticks, control functions, instrumentation, temperature sensing, etc. T1 sound generator, software controlled music, Votrax voice synthesizer and real time clock calendar add to its versatility.

A standard 60-pin bus with 5 slots, parallel ports and 2 serial ports with full handshaking (75 to 9600 BAUD) allow expansion into floppy disks, color, EPROM programmer, printer, modem of your choice. Later expansion will add a light pen, a universal user programmable music sound board, General Purpose Instrument Bus, and a high resolution color/grayscale pixel mapped video board.

VENTURE connects directly to a monitor or to your TV set through an RF modulator. And now for the heart of VENTURE . . . its video display. VENTURE has a high resolution programmable video display with up to 4096 user-defined characters, alphanumeric symbols, special graphics or objects, such as space ships, etc. Each character is 8 pixels wide by 15 pixels high, with 2 grayscale maps; it has 64 levels of grayscale plus video invert/compliment and hidden screen update for a "snow" free display. The display is 512 x 512 pixel mapped with 2 planes of video RAM per display. VENTURE video is in short . . . astounding!

VENTURE has complete software support with full BASIC, 3 ROM monitors, disassembler/assembler/editor. It will run real-time video games, all RCA chip 8 programs and all current Quest 1802 software. VENTURE DOS will accommodate up to three 5¼" double density floppies. A complete 1802 programming book is available. All versions of VENTURE are shipped with a set of manuals written to be understood by the inexperienced as well as experienced user.

On-Board Options
16 channel A to D; 5 slot 60 pin bus, 2 serial ports, parallel ports; 3 video options, 48K RAM, Votrax voice synthesizer, sound generator, EPROM; full BASIC dissassembler, editor, assembler; metal cabinet, additional power supply, ASCII keyboard real time clock calendar.

Expansion Options
Floppy disk, EPROM programmer, light pen, universal user programmable music, sound board high resolution color/grayscale pixel mapped video board, General Purpose Instrument Bus.

Minimum VENTURE System $195.00
Kit includes CPU and control with 4K of RAM, 1K of scratchpad, 2K monitor, 1861 video graphics, cassette interface and separate HEX keyboard with LED displays for address and output. Power supply is included along with 2 game cassettes. The main board is 16" x 20" and includes space for all of the previously discussed on-board options. Full on-board expansion can be completed for under $1000.00. Call for further details, option prices, etc.

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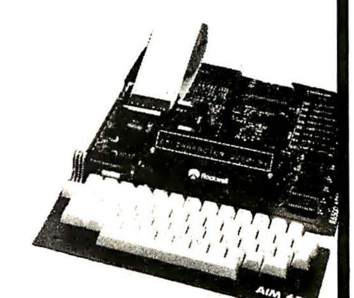
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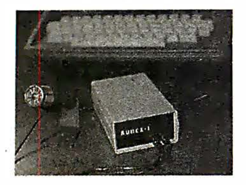
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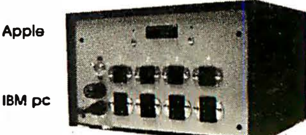
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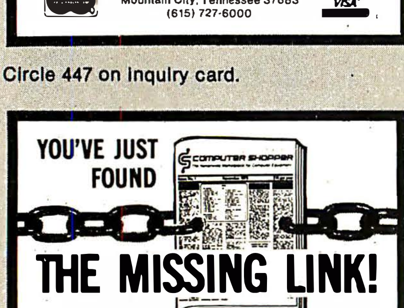
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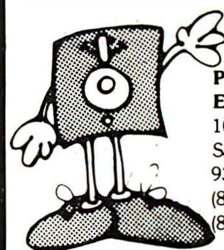
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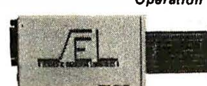
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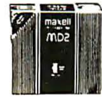
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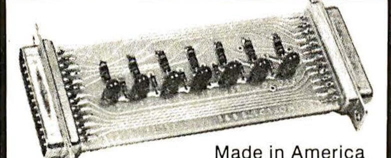
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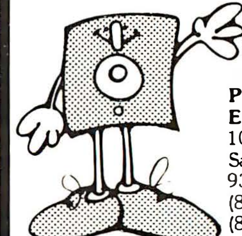
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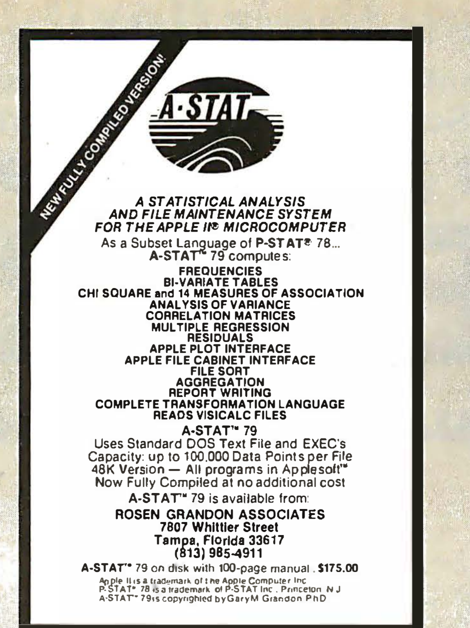
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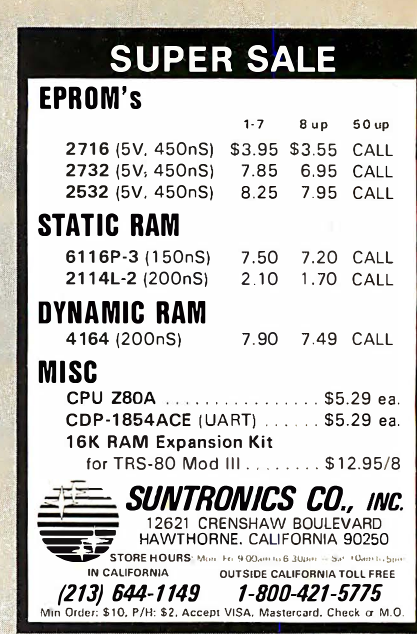


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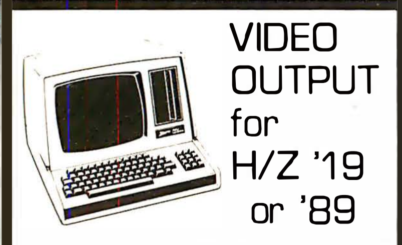
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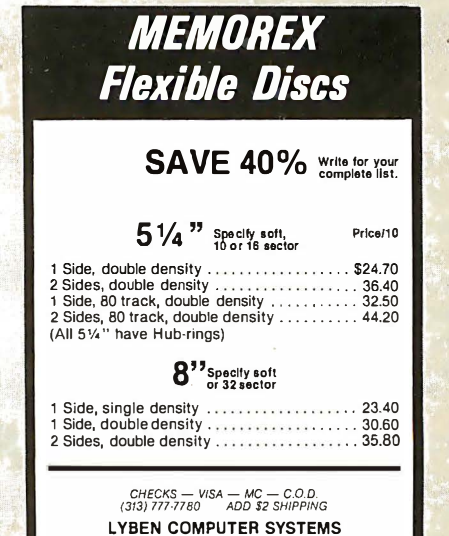
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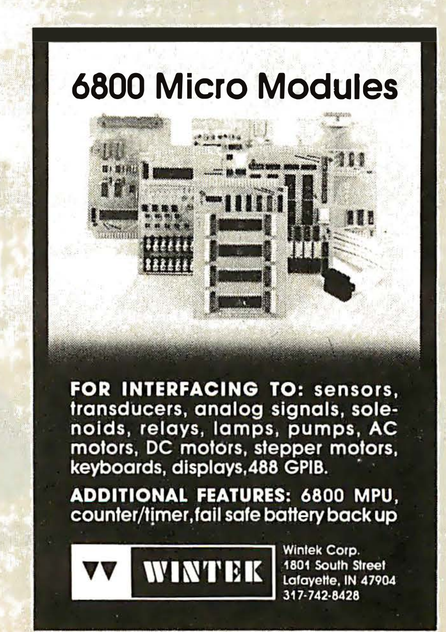
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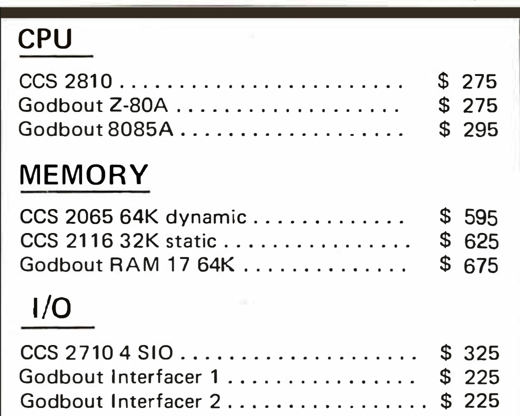
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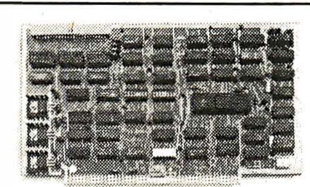
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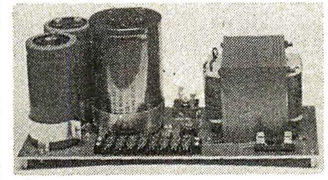
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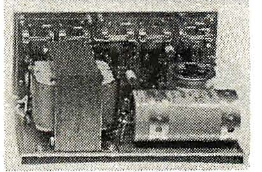
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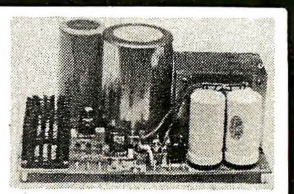
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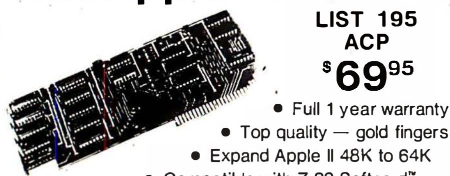


Circle 442 on inquiry card.

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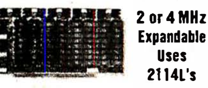
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2 or 4 MHz
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Voffset = 1.0 mV
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8205	2.69	6810	4.75	6520	6.95
8212	2.75	6820	6.50	6522	9.95
8214	4.95	6821	6.50	6530-X	24.95
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2716/2516; 5V (2Kx8) TS	7.95	1702A	5.75
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16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
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28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

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10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
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20 pin WW	1.15	1.08	.99
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LM377N	2.75	CA3160T	1.19
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NE555V	.39	LM3905N	1.19
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LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
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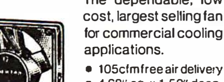
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74S08	.49	74S138	1.29	74S260	.75
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74S10	.42	74S140	.73	74S287	2.99
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74S64	.46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
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74S112	.72	74S242	2.99	74S940	2.90
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7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7465	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74276	1.89
7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
7474	.34			74490	1.90

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74LS00	$ .26	74LS113	$ .43	74LS245	$2.20
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74LS02	.28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	.95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	.59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS98	1.69
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4006	1.05	4042	.95	4098	2.29
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4010	.45	4047	1.25	14410	12.95
4011	.35	4048	.99	14412	12.95
4012	.25	4049	.45	14415	8.95
4013	.45	4050	.69	14419	4.95
4014	1.39	4051	1.10	4501	.39
4015	1.15	4052	1.10	4502	1.65
4016	.59	4053	1.10	4503	.69
4017	1.19	4055	3.95	4505	8.95
4018	.89	4056	2.95	4506	.75
4019	.45	4059	9.25	4507	.95
4020	1.10	4060	1.39	4508	3.75
4021	1.19	4066	.75	4510	1.19
4022	1.15	4069	.35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
4029	1.29	4076	1.29	4555	4.95
4030	.45	4077	.35	4556	.99
4031	3.25	4078	.35	4566	2.25
4032	2.15	4081	.35	80C95	1.50
4034	3.25	4082	.35	80C97	1.25
4035	.95	4085	1.95		

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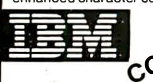
Vista COMPUTER

Vision 80
as reviewed in
May BYTE pg. 266

This is the widely discussed Cadillac 80 column card for the Apple II. The Vision 80 responds to more Apple text screen commands than any other board. It supports PASCAL, Microsofts Z80 Softcard and can be used as an intelligent terminal.

List Price.... $395.00 **Special Low Price.... $269.00**

The Vision 80 can also be used in conjunction with the Vision 40 (allows enhanced character sets) and the Vision 20 for lower case.



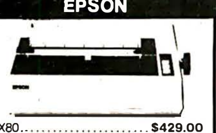
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EPSON



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MX100FT	725.00
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Serial I/O w/cable	95.00
Serial I/O w/2k & cable	129.00
Grapf Tax	89.00
Printer Pal (P80)	29.95
Printer Pal (P100)	39.95





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40 CPS Daisy Wheel $1475

PRO-WRITER 8510A
120 CPS Dot Matrix Parallel ... 599

DIABLO 630



Diablo 630RO
$2095

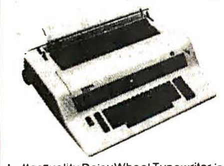
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Dot Resolution Graphics • 9-wire stag. printhead • Lowercase decenders • Over 150cps • Bi-directional, logic seeking • 8 character sizes • 80-132 col. • Hi-res dot graphics • Proportional spacing • Text justification.

	LIST	ACP
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IDS Paper Tiger 560G	1395	1099
Prism 132 (color)	1995	1875

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	LIST	ACP
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ES100 Typewriter Print	1195	1050
GQ10 Apple I/O card	349	169
GQ11 Other I/O's	349	299
I/O Cable	49	29

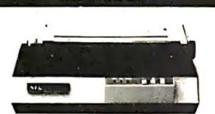
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• 120 cps • Logic seeking • Double width & condensed print • Font seletion, character pitch & line spacing program controllable • Bi-directional printing

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Apple Cable	19.95
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5109CX 9" Green	220	179
8012C 12" B/W	250	219
8012CX 12" Green	260	229
6013 13" Color	470	422
6113 13" RGB	995	889
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2012 12" B/W	145	139
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Apple II System Special w/64K, Z80 Card, Vision 80	2519.00	1775.00
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ProFile Hard Disk Drive	3499.00	2899.00
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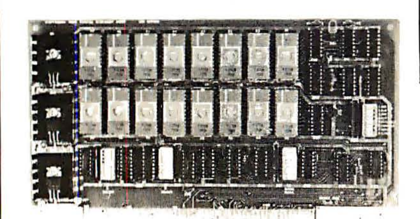
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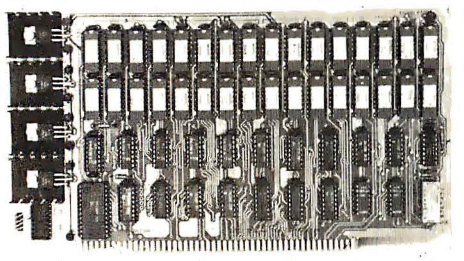
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4. ON BOARD SELECTABLE WAIT STATES.
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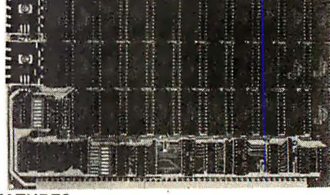
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- 200 NS RAMs are standard. (TOSHIBA makes TMM 2016s as fast as 100 NS. FOR YOUR HIGH SPEED APPLICATIONS.)
- Board is configured as 3-16K blocks and 8-2K blocks (within any 64K block) for maximum flexibility.
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TR1602B

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National S... MM5257. Arranged 4K x 1. +5V, 18 PIN DIP. A Lower Po... R... cement for TMS 4044. 450 NS. Several Boards on the... Wi... Rams. SUPER SURPLUS PURCHASE! PRIME NEW ... TS

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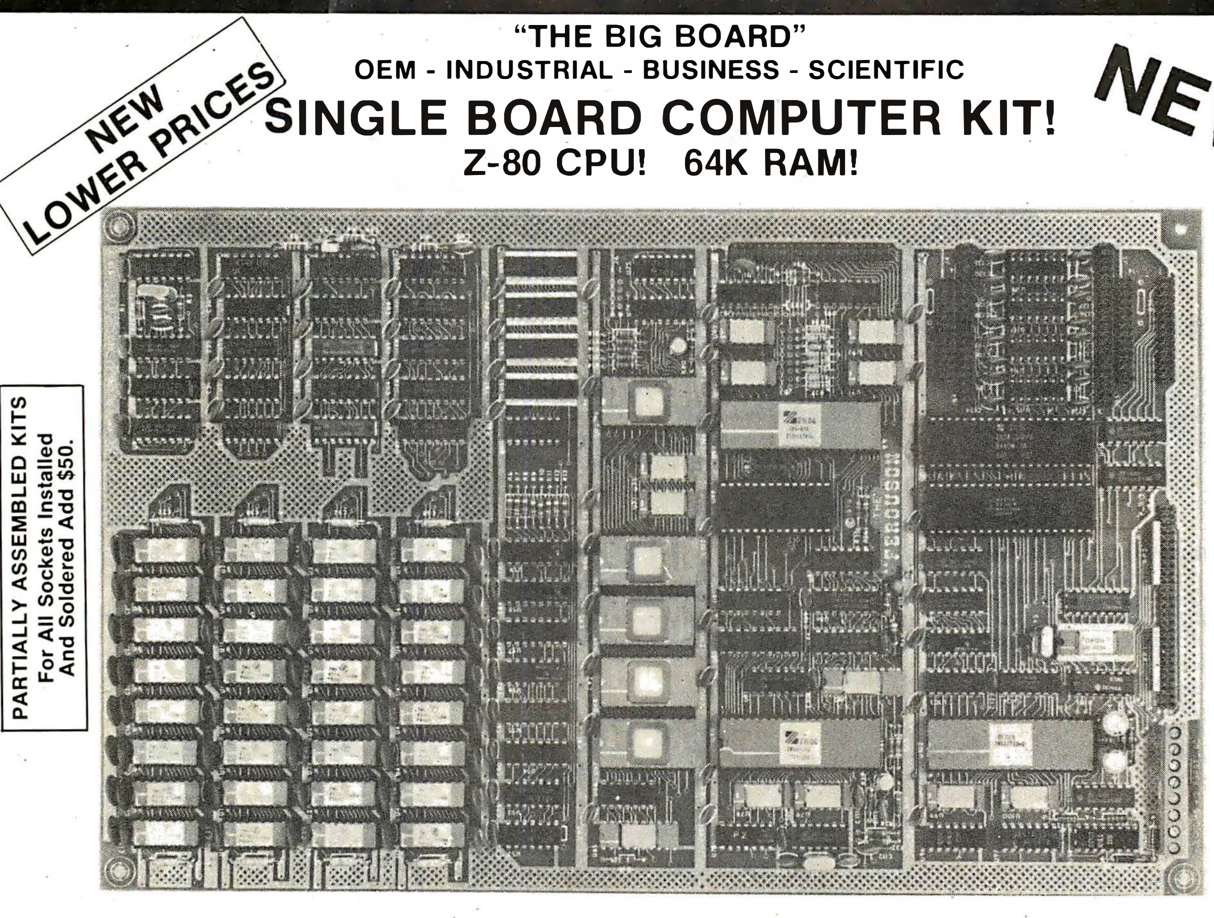
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FEATURES: (Remember, all this on one board!)

64K RAM

Uses industry standard 4116 RAM'S. All 64K is available to the user, our VIDEO and EPROM sections do not make holes in system RAM. Also, very special care was taken in the RAM array PC layout to eliminate potential noise and glitches.

Z-80 CPU

Running at 2.5 MHZ. Handles all 4116 RAM refresh and supports Mode 2 INTERUPTS. Fully buffered and runs 8080 software.

SERIAL I/O (OPTIONAL)

Full 2 channels using the Z80 SIO and the SMC 8116 Baud Rate Generator. FULL RS232! For synchronous or asynchronous communication. In synchronous mode, the clocks can be transmitted or received by a modem. Both channels can be set up for either data-communication or data-terminals. Supports mode 2 Int. Price for all parts and connectors: $49

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Consists of a separate parallel port (Z80 PIO) for use with an ASCII encoded keyboard for input. Output would be on the 80 x 24 Video Display.

24 x 80 CHARACTER VIDEO

With a crisp, flicker-free display that looks extremely sharp even on small monitors. Hardware scroll and full cursor control. Composite video or split video and sync. Character set is supplied on a 2716 style ROM, making customized fonts easy. Sync pulses can be any desired length or polarity. Video may be inverted or true. 5 x 7 Matrix - Upper & Lower Case

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Uses WD1771 controller chip with a TTL Data Separator for enhanced reliability. IBM 3740 compatible. Supports up to four 8 inch disc drives. Directly compatible with standard Shugart drives such as the SA800 or SA801. Drives can be configured for remote AC off-on. Runs CP/M* 2.2.

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BLANK PC BOARD — $149

The blank Big Board PC Board comes complete with full documentation (including schematics), the character ROM, the PFM 3.3 MONITOR ROM, and a diskette with the source of our BIOS, BOOT, and PFM 3.3 MONITOR.

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Z-80 is a Trademark of Zilog.

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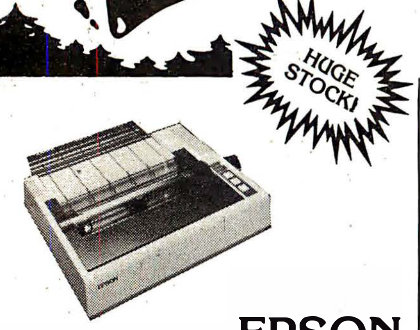
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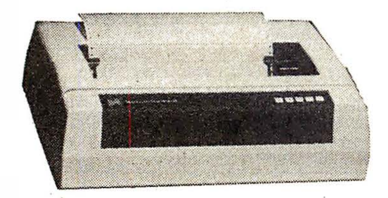
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C. ITOH
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F10 List $1795 .... CALL

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Interface Card .... ADD 350.

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ES 100 Typewriter Only List $1195 .... $895.
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(specify serial or parallel)
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Smith-Corona TP-1 List $895 .... $695

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3510/3530 RO .... 1695.
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88G List $749 .... $519.
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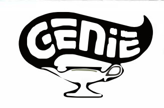
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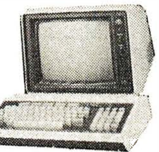
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HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	8.95
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5V = single 5 volt supply

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5v = Single 5 Volt Supply

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PE-14		6	5,200	83.00
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PE-24T	X	9	6,700	175.00
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Z80A-SIO/2	22.50
Z80A-SIO/9	19.95

6.0 Mhz

Z80B-CPU	17.95
Z80B-CTC	15.50
Z80B-PIO	15.50

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.0	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

DATA ACQUISITION

ADC0800	15.55
ADC0804	4.95
ADC0809	5.25
ADC0817	10.95
DAC0800	4.95
DAC0806	2.25
DAC0808	4.95
DAC1020	8.25
DAC1022	8.25
MC1408L6	2.25
MC1408L8	4.95

8000

8035	7.25
8039	7.95
INS-8060	17.95
INS-8073	29.95
8080	3.95
8085	7.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	7.95
8156	8.95
8185	29.95
8185-2	39.95
8741	39.95
8748	29.95
8755	32.00

8200

8202	29.95
8203	39.95
8205	3.50
8212	1.85
8214	3.85
8216	1.80
8224	2.50
8226	1.80
8228	4.90
8237	19.95
8238	4.95
8243	4.45
8250	14.95
8251	4.75
8253	9.25
8253-5	9.85
8255	4.75
8255-5	5.25
8257	8.50
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	9.50
8279-5	10.00
8282	6.65
8283	6.65
8284	5.70
8286	6.65
8287	6.50
8288	25.00
8289	49.95

FUNCTION GENERATORS

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

INTERSIL

ICL7103	9.50
ICL7106	9.95
ICL7107	12.95
ICL8038	3.95
ICM7107A	5.59
ICM7208	15.95

6800

68000	99.95
6800	4.95
6802	10.95
6808	13.90
6809E	19.95
6809	12.95
6810	2.95
6820	4.95
6821	4.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	12.25
6850	3.45
6852	5.75
6860	10.95
6862	11.95
6875	6.95
6880	2.95
6883	24.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	7.95
68B21	12.95
68B45	35.95
68B50	12.95

68B00 = 2 MHZ

6500

1 MHZ

6502	5.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	8.75
6532	11.25
6545	22.50
6551	11.85

2 MHZ

6502A	9.95
6522A	11.70
6532A	12.40
6545A	28.50
6551A	12.95

3 MHZ

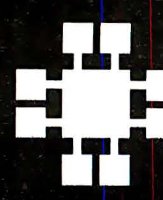
6502B	14.95

EXAR

XR 2206	3.75
XR 2207	3.85
XR 2208	3.90
XR 2211	5.25
XR 2240	3.25

9000 SERIES

9316	1.00
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
96S02	1.95



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Circle 253 on inquiry card.

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2732 32K EPROMS $6.95 EACH

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74LS00

74LS00	.25	74LS86	.40	74LS169	1.75	74LS323	2.75
74LS01	.25	74LS90	.65	74LS170	1.75	74LS324	1.75
74LS02	.25	74LS91	.89	74LS173	.80	74LS352	1.55
74LS03	.25	74LS92	.70	74LS174	.95	74LS353	1.55
74LS04	.25	74LS93	.65	74LS175	.95	74LS363	1.35
74LS05	.25	74LS95	.85	74LS181	2.15	74LS364	1.95
74LS08	.35	74LS96	.95	74LS189	9.95	74LS365	.95
74LS09	.35	74LS107	.40	74LS190	1.00	74LS366	.95
74LS10	.25	74LS109	.40	74LS191	1.00	74LS367	.70
74LS11	.35	74LS112	.45	74LS192	.85	74LS368	.70
74LS12	.35	74LS113	.45	74LS193	.95	74LS373	1.75
74LS13	.45	74LS114	.50	74LS194	1.00	74LS374	1.75
74LS14	1.00	74LS122	.45	74LS195	.95	74LS377	1.45
74LS15	.35	74LS123	.95	74LS196	.85	74LS378	1.18
74LS20	.25	74LS124	2.99	74LS197	.85	74LS379	1.35
74LS21	.35	74LS125	.95	74LS221	1.20	74LS385	1.90
74LS22	.25	74LS126	.85	74LS240	1.29	74LS386	.65
74LS26	.35	74LS132	.75	74LS241	1.29	74LS390	1.90
74LS27	.35	74LS133	.89	74LS242	1.85	74LS393	1.90
74LS28	.35	74LS136	.55	74LS243	1.85	74LS395	1.65
74LS30	.25	74LS137	.99	74LS244	1.29	74LS399	1.70
74LS32	.35	74LS138	.75	74LS245	1.90	74LS424	2.95
74LS33	.55	74LS139	.75	74LS247	.75	74LS447	.37
74LS37	.55	74LS145	1.20	74LS248	1.25	74LS490	1.95
74LS38	.35	74LS147	2.49	74LS249	.99	74LS624	3.99
74LS40	.35	74LS148	1.35	74LS251	1.30	74LS668	1.69
74LS42	.55	74LS151	.75	74LS253	.85	74LS669	1.89
74LS47	.75	74LS153	.75	74LS257	.85	74LS670	2.20
74LS48	.75	74LS154	2.35	74LS258	.85	74LS674	9.65
74LS49	.75	74LS155	1.15	74LS259	2.85	74LS682	3.20
74LS51	.25	74LS156	.95	74LS260	.65	74LS683	3.20
74LS54	.35	74LS157	.75	74LS266	.55	74LS684	3.20
74LS55	.35	74LS158	.75	74LS273	1.65	74LS685	3.20
74LS63	1.25	74LS160	.90	74LS275	3.35	74LS688	2.40
74LS73	.40	74LS161	.95	74LS279	.55	74LS689	3.20
74LS74	.45	74LS162	.95	74LS280	1.98	74LS783	24.95
74LS75	.50	74LS163	.95	74LS283	1.00	81LS95	1.69
74LS76	.40	74LS164	.95	74LS290	1.25	81LS96	1.69
74LS78	.50	74LS165	.95	74LS293	1.85	81LS97	1.69
74LS83	.75	74LS166	2.40	74LS295	1.05	81LS98	1.69
74LS85	1.15	74LS168	1.75	74LS298	1.20	25LS2521	2.80
						25LS2569	4.25

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call
ZIF = TEXTOOL (Zero Insertion Force)		

CONNECTORS

RS232 MALE	3.25
RS232 FEMALE	3.75
RS232 FEMALE RIGHT ANGLE	5.25
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

DIP SWITCHES

4 POSITION	.85
5 POSITION	.90
6 POSITION	.90
7 POSITION	.95
8 POSITION	.95

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.65
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.40
7413	.35	74155	.75
7414	.55	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.70
7422	.29	74162	.85
7423	.29	74163	.85
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.59	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74186	18.50
7453	.23	74190	1.15
7454	.23	74191	1.15
7460	.23	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.35	74196	.79
7475	.49	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7485	.65	74248	1.85
7486	.35	74249	1.95
7489	4.95	74251	.75
7490	.35	74259	2.25
7491	.40	74265	1.35
7492	.50	74273	1.95
7493	.49	74276	1.25
7494	.65	74279	.75
7495	.55	74283	2.00
7496	.70	74284	3.75
7497	2.75	74285	3.75
74100	1.75	74290	.95
74107	.30	74293	.75
74109	.45	74298	.85
74110	.45	74351	2.25
74111	.55	74365	.65
74116	1.55	74366	.65
74120	1.20	74367	.65
74121	.29	74368	.65
74122	.45	74376	2.20
74123	.55	74390	1.75
74125	.45	74393	1.35
74126	.45	74425	3.15
74128	.55	74426	.85
		74490	2.55

CMOS

4000	.35	4528	1.25
4001	.35	4531	.95
4002	.25	4532	1.95
4006	.95	4538	1.95
4007	.29	4539	1.95
4008	.95	4543	2.70
4009	.45	4555	.95
4010	.45	4556	.95
4011	.35	4581	1.95
4012	.25	4582	1.95
4013	.45	4584	.95
4014	.95	4585	.95
4015	.95	4702	12.95
4016	.45	74C00	.35
4017	1.15	74C02	.35
4018	.95	74C04	.35
4019	.45	74C08	.35
4020	.95	74C10	.35
4021	.95	74C14	1.50
4022	1.15	74C20	.35
4023	.35	74C30	.35
4024	.75	74C32	.50
4025	.35	74C42	1.75
4026	1.65	74C48	1.20
4027	.65	74C73	.65
4028	.80	74C74	.85
4029	.95	74C76	.80
4030	.45	74C83	1.95
4034	2.95	74C85	1.95
4035	.85	74C86	.95
4040	.95	74C89	4.50
4041	1.25	74C90	1.75
4042	.75	74C93	1.75
4043	.85	74C95	1.75
4044	.85	74C107	1.00
4046	.95	74C150	5.75
4047	.95	74C151	2.25
4049	.55	74C154	3.25
4050	.55	74C157	1.75
4051	.95	74C160	2.00
4053	.95	74C161	2.00
4060	1.45	74C162	2.00
4066	.75	74C163	2.00
4068	.40	74C164	2.00
4069	.35	74C165	2.00
4070	.35	74C173	2.00
4071	.30	74C174	2.25
4072	.30	74C175	2.25
4073	.30	74C192	2.25
4075	.30	74C193	2.25
4076	.95	74C195	2.25
4078	.30	74C200	5.75
4081	.30	74C221	2.25
4082	.30	74C373	2.75
4085	.95	74C374	2.75
4086	.95	74C901	.80
4093	.95	74C902	.85
4098	2.49	74C903	.85
4099	1.95	74C905	10.95
14409	12.95	74C906	.95
14410	12.95	74C907	1.00
14411	11.95	74C908	2.00
14412	12.95	74C909	2.75
14419	4.95	74C910	9.95
4502	.95	74C911	10.00
4503	.65	74C912	10.00
4508	1.95	74C914	1.95
4510	.95	74C915	2.00
4511	.95	74C918	2.75
4512	.95	74C920	17.95
4514	1.25	74C921	15.95
4515	2.25	74C922	5.59
4516	1.55	74C923	5.95
4518	1.25	74C925	6.75
4519	1.25	74C926	7.95
4520	1.25	74C927	7.95
4522	1.25	74C928	7.95
4526	1.25	74C929	19.95
4527	1.95	74C930	19.95

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74S00	.32	74S163	1.95
74S02	.35	74S168	3.95
74S03	.35	74S169	3.95
74S04	.35	74S174	1.09
74S05	.35	74S175	1.09
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	2.25
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.95	74S374	2.45
74S139	.95	74S381	7.95
74S140	.55	74S387	1.95
74S151	.95	74S412	2.98
74S153	.95	74S471	5.45
74S157	.95	74S472	5.45
74S158	.95	74S474	7.95
74S161	1.95	74S482	15.25
74S162	1.95	74S570	4.25
		74S571	4.25





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- ★ **Very competitive prices!**
- ★ **Friendly staff!**
- ★ **Fast service — most orders shipped within 24 hours!**

LED DISPLAYS

HP 5082-7760	.6″	CC	1.29
MAN 72	.3″	CA	.99
MAN 74	.3″	CC	.99
FND-357 (359)	.375″	CC	.75
FND-500 (503)	.5″	CC	.99
FND-507 (510)	.5″	CA	.99

LED LAMPS

	1-99	100-up
Jumbo Red	.10	.09
Jumbo Green	.18	.15
Jumbo Yellow	.18	.15

TRANSISTORS DIODES

PN2222	NPN SWITCH	TO-92	10/1.00	100/8.99
PN2907	PNP SWITCH	TO-92	10/1.25	100/10.99
2N2222	NPN SWITCH	TO-18	.25	50/10.99
2N2907	PNP SWITCH	TO-18	.25	50/10.99
2N3055	NPN POWER	TO-3	.79	10/6.99
3055T	NPN POWER	TO-220	.69	10/5.99
2N3904	NPN SWITCH	TO-92	10/1.00	100/8.99
2N3906	NPN SWITCH	TO-92	10/1.00	100/8.99
IN4148 (IN914)	SWITCHING		25/1.00	1000/35.00
IN4004	RECTIFIER		10/1.00	100/8.99

Circle 253 on inquiry card.

FLOPPY DISK DRIVE

LINEAR

LM301	.34	LM350K	5.60	NE570	4.75	LM1800	2.99
LM301H	.79	LM350T	4.60	NE571	3.95	LM1812	8.25
LM307	.45	LM358	.98	NE592	2.75	LM1815	5.20
LM308	.98	LM359	1.79	LM703	.89	LM1818	2.90
LM308H	1.15	LM376	3.75	LM709	.59	LM1820	3.50
LM309H	1.95	LM377	2.29	LM710	.75	LM1830	3.50
LM309K	1.49	LM378	2.50	LM711	.79	LM1871	5.49
LM310	1.75	LM379	4.50	LM723	.49	LM1872	5.49
LM311	.64	LM380	1.29	LM723H	.55	LM1877	3.25
LM311H	.89	LM380N-8	1.10	LM733	.98	LM1889	2.49
LM312H	1.75	LM381	1.60	LM741N-8	.35	LM1896	1.75
LM317K	3.95	LM382	1.60	LM741N-14	.35	LM2877	2.05
LM317T	1.95	LM383	1.95	LM741H	.40	LM2878	2.25
LM318	1.49	LM384	1.95	LM747	.79	LM2900	.85
LM318H	1.59	LM386	1.50	LM748	.59	LM2901	1.00
LM319H	1.25	LM387	1.40	LM1014	2.75	LM3900	.59
LM319	1.25	LM389	1.35	LM1303	1.95	LM3905	1.25
LM320(see 7900)		LM390	1.95	LM1304	1.19	LM3909	.98
LM322	1.65	LM392	.69	LM1305	1.49	LM3911	2.25
LM323K	4.95	LM394H	4.60	LM1307	.85	LM3914	3.95
LM324	.59	LM399H	5.00	LM1310	2.90	LM3915	3.95
LM329	.69	NE531	3.75	MC1330	1.89	LM3916	3.95
LM331	3.95	NE536	6.00	MC1349	1.89	MC4024	3.95
LM334	1.30	NE555	.39	MC1350	1.29	MC4044	4.50
LM335	1.40	NE556	.69	MC1358	1.79	RC4136	1.25
LM336	1.75	NE558	1.50	LM1414	1.59	RC4151	3.95
LM337K	3.95	NE561	19.95	LM1458	.69	LM4250	1.75
LM337T	2.95	NE562	6.00	LM1488	.99	LM4500	3.25
LM338K	6.95	NE564	3.95	LM1489	.99	LM13080	1.29
LM339	.99	LM565	.99	LM1496	.85	LM13600	1.49
LM340 (see 7800)		LM566	1.49	LM1558H	3.10	LM13700	1.49
LM348	1.20	LM567	1.29				

H = TO-5 CAN T = TO-220 K = TO-3

RCA

CA 3010	.99	CA 3081	1.65
CA 3013	2.00	CA 3082	1.65
CA 3023	2.75	CA 3083	1.55
CA 3035	2.49	CA 3086	.80
CA 3039	1.29	CA 3089	2.99
CA 3046	1.25	CA 3096	3.49
CA 3053	1.45	CA 3130	1.30
CA 3059	2.90	CA 3140	1.15
CA 3060	2.90	CA 3146	1.85
CA 3065	1.75	CA 3160	1.19
CA 3080	1.10	CA 3401	.59
		CA 3600	3.45

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
		75494	.89

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
		LF357	1.40

VOLTAGE REGULATORS

7805T	.89	7905T	.99
7808T	.89	7908T	.99
7812T	.89	7912T	.99
7815T	.89	7915T	.99
7824T	.89	7924T	.99
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79
78H05K	9.95	LM323K	4.95
78H12K	9.95	UA78S40	1.95

T = TO-220 K = TO-3
L = TO-92

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STATIC

2k x 8 TMM2016-200NS $5.95 EA.

1k x 1 2102L-450NS 100/$75

DYNAMIC

64k x 1 4164-200NS $7.25

4k x 1 4027-250NS $1.95

CPU SALE

8 BIT

Z-80 CPU 2MHZ	$3.95	(10/ 3.75 EA)
6502 1 MHZ	$5.95	(10/ 5.75 EA)
6809 INT. CLOCK	$12.95	(10/11.25 EA)

16 BIT

8086	$29.95
68000 8MHZ	$99.95

BAUD-RATE GENERATORS

MC14411	7.95	10/7.25
1.8432 CRYSTAL	4.95	
4702	8.95	10/7.95
2.4576 CRYSTAL	4.95	

TRANSISTORS

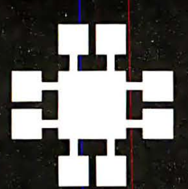
PN2222	1000/69.00
2N3904	1000/69.00
2N3906	1000/69.00

IC SOCKETS LOW PROFILE SOLDERTAIL

HIGH RELIABILITY
DUAL SIDE WIPE STYLE

	100 pcs	1000 pcs
8 pin	.08	.075
14 pin	.09	.085
16 pin	.09	.085
18 pin	.12	.110
24 pin	.20	.150
40 pin	.22	.190

SALE ENDS SEPTEMBER 30, 1982



JDR MICRODEVICES, INC.
1224 S. Bascom Avenue
San Jose, CA 95128
800-538-5000 • 800-662-6279 (CA)
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PLEASE USE YOUR CUSTOMER NUMBER WHEN ORDERING

TERMS: For shipping include $2 for UPS Ground or $3 for UPS Blue Label Air. Items over 5 pounds require additional shipping charges. Foreign orders include sufficient amount for shipping. There is a $10 minimum order. Bay Area and Los Angeles Counties add 6½% Sales Tax. Other California residents add 6% Sales Tax. We reserve the right to substitute manufacturer. Not responsible for typographical errors. Prices are subject to change without notice. We will match or beat any competitor's price provided it is not below our cost.

Circle 254 on inquiry card.

FOR YOUR APPLE* $299.95

IDC CONNECTORS

DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	1.20	1.20	2.60	2.60	1.88	---	3.95
20	1.90	1.90	4.15	4.15	2.75	5.50	4.35
26	2.75	2.75	5.35	5.35	3.50	6.25	5.00
34	3.20	3.20	6.25	6.25	4.50	7.00	6.05
40	3.75	3.75	7.35	7.35	5.40	7.50	6.90
50	4.75	4.75	9.20	9.20	6.50	8.50	8.50

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "**xx**" of the "order by" part number listed. **Example:** A 10 pin right angle solder style header would be IDH**10**SR.

D-SUBMINIATURE

DESCRIPTION	SOLDER		RIGHT ANGLE SOLDER		RIBBON CABLE		HOODS	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	BLACK	GREY
ORDER BY	DBxxP	DBxxS	DBxxPR	DBxxSR	IDBxxP	IDBxxS	HOOD-B	HOOD
CONTACTS 9	2.08	2.66	4.83	5.04	4.80	5.22	---	2.25
15	2.69	3.63	5.82	6.27	6.57	5.22	---	2.25
25	3.25	3.75	7.44	8.49	8.61	9.42	1.25	1.25
37	4.80	7.11	9.39	10.95	9.30	11.50	---	2.95
50	6.06	9.24	---	---	---	---	---	3.50

For order instructions see "IDC Connectors" above.

ORDER TOLL FREE

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800-662-6279

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IF YOU CAN FIND A PRICE LOWER ELSEWHERE, LET US KNOW AND WE'LL MEET OR BEAT THEIR PRICE!
(SEE TERMS BELOW)

- ★ **Computer managed inventory— virtually no back orders!**
- ★ **Very competitive prices!**
- ★ **Friendly staff!**
- ★ **Fast service — most orders shipped within 24 hours!**

DIP CONNECTORS

DESCRIPTION	AUGAT STYLE TOOLED ST IC SOCKETS	COMPONENT CARRIERS	RIBBON CABLE DIP PLUGS
ORDER BY	AUGATxx-ST	ICCxx	IDPxx
CONTACTS 8		.65	
14		.75	1.45
16	.99	.85	
18		1.00	
20		1.25	
22		1.25	
24	1.99	1.35	2.50
28		1.50	
40		2.10	4.15

For order instructions see "IDC Connectors" above.

MasterCard



RIBBON CABLE

CONTACTS	GREY 1'	GREY 10'	COLOR CODED 1'	COLOR CODED 10'
10	.50	4.40	.83	7.30
20	.65	5.70	1.25	11.00
26	.75	6.60	1.32	11.60
34	.98	8.60	1.65	14.50
40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

BOOKS — BEST SELLERS

OSBORNE/MC GRAW-HILL

- Apple II User's Guide 14.95
- CRT Controller's Handbook 6.99
- 68000 Assembly Language Programming 16.99
- CBASIC User Guide 15.00

SYBEX

- Your First Computer 8.95
- The CP/M Handbook 14.95
- The PASCAL Handbook 18.95
- Microprocessor Interfacing Techniques 17.95

BEST SELLING OK MACHINE & TOOL PRODUCTS

ID WRAP

A SMALL PLASTIC LABEL THAT SLIPS OVER A WIRE WRAP SOCKET THAT LABELS THE PIN NUMBERS ON THE WIRE SIDE OF THE SOCKET.

14 PIN	10/1.83
16 PIN	10/1.83
18 PIN	5/1.83
20 PIN	5/1.83
22 PIN	5/1.83
24 PIN	5/1.83
28 PIN	5/1.83
40 PIN	5/1.83

WRAP/UNWRAP/STRIP TOOL

THIS TOOL WILL WRAP, UNWRAP & STRIP STANDARD 30 GAUGE SOLID WIRE WRAP WIRE. THE MODIFIED VERVE10N WILL WRAP 1½ TURNS OF INSULATION BEFORE IT WRAPS THE SOLID WIRE.

WSU-30	8.09
WSU-30M	9.17

EXTRACTOR TOOLS

EX-1 14-20 PIN	2.11
EX-2 24-40 PIN	10.75

WIRE DISPENSER

CUTS & STRIPS TO ANY LENGTH 50 FT. SPPOL. CHOICE OF BLUE, YELLOW, RED OR WHITE.

5.93

TRI-COLOR DISPENSER

50 FT. EACH, RED, BLUE & WHITE

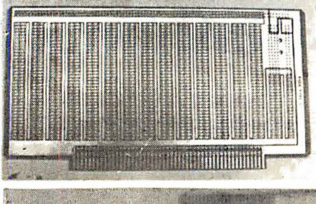
9.17

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ALL MERCHANDISE 100% GUARANTEED! CALL US FOR VOLUME QUOTES

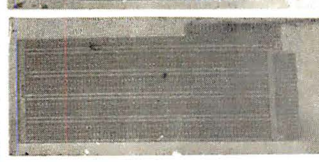
WIREWRAP PROTOTYPE CARDS

FR-4 Epoxy Glass Laminate with Gold Plated Contact Fingers



S-100 BUSS

P100-1	Bare — No Foil Pads	15.95
P100-2	Horizontal BUSS	22.95
P100-3	Vertical BUSS	22.95
P100-4	Single Foil Pads Per Hole	23.95
S100-ST	Solder Tail Edge Connector	3.95
S100-WW	Wire Wrap Edge Connector	4.95



APPLE

P500-1	Bare — No Foil Pads	15.95
P500-3	Horizontal BUSS	22.95
P500-4	Single Foil Pads Per Hole	23.95
50P-ST	50 Pin Edge Connector	3.95

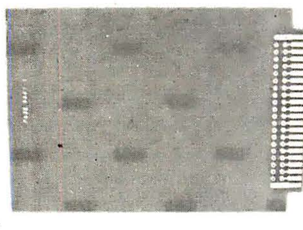


IBM

IBM-PR	BUSS Lines + Pads	55.00

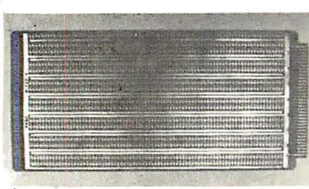
GENERAL PURPOSE

22/44 PIN (.156" SPACING)



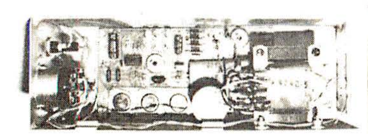
P441-1	Bare — No Foil Pads, 4.5" x 6"	9.95
P442-1	Bare — No Foil Pads, 4.5" x 9"	10.95
P441-3	Vertical BUSS, 4.5" x 6"	13.95
P442-3	Vertical BUSS, 4.5" x 9"	14.95
P441-4	Single Foil Pads Per Hole, 4.5"x6"	14.95
P442-4	Single Foil Pads Per Hole, 4.5"x9"	15.95
44P-ST	Solder Tail Edge Connector	3.95
44P-WW	Wire Wrap Edge Connector	4.95

36/72 PIN (.1" SPACING)



P721-1	Bare — No Foil Pads, 4.5" x 6"	9.95
P722-1	Bare — No Foil Pads, 4.5" x 9"	10.95
P721-3	Vertical BUSS, 4.5" x 6"	13.95
P722-3	Vertical BUSS, 4.5" x 9"	14.95
P721-4	Single Foil Pads Per Hole, 4.5"x6"	14.95
P722-4	Single Foil Pads Per Hole, 4.5"x9"	15.95
72P-ST	Solder Tail Edge Connector	6.95
22P-WW	Wire Wrap Edge Connector	7.95

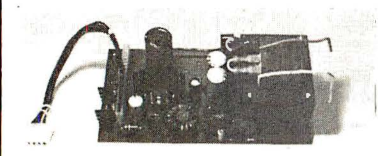
POWER SUPPLIES



MODEL 1 $29^95

OPEN FRAME STYLE
MANUFACTURED BY SIGMA
+5 VOLT 4 AMP





MODEL 2 $39^95

MOUNTED ON PC BOARD
MANUFACTURED BY CONVER
+5 VOLT 4 AMP
+12 VOLT 1 AMP
-12 VOLT 1 AMP

FOR SHIPPING PLEASE INCLUDE $4.00 FOR UPS GROUND; $13.00 FOR UPS BLUE LABEL

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5¼"

ATHANA	SS SD SOFT	24.95
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VERBATIM	SS SD SOFT	29.95
VERBATIM	10 SECTION HARD	29.95

8"

VERBATIM	SS SD SOFT	44.95

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TANDON

TM100-1 (POR IBM PC) 229.00

SHUGART

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CABINET FOR 5¼" DISK DRIVE

★ COLOR MATCHES APPLE
★ FITS SHUGART

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MICROCOMPUTER HARDWARE HANDBOOK

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Over 800 pages of manufacturers data sheets on most commonly used IC's.

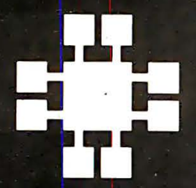
Includes:
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Circle 255 on inquiry card.

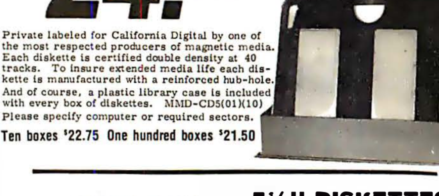
Circle 255 on Inquiry card.

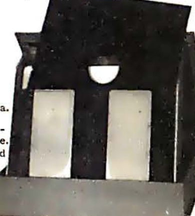
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FREE PLASTIC LIBRARY CASE INCLUDED WITH THE PURCHASE OF EVERY BOX OF DISKETTES





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Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life each diskette is manufactured with a reinforced hub-hole. And of course, a plastic library case is included with every box of diskettes. MMD-CD5(01)(10) Please specify computer or required sectors.

Ten boxes $22.75 One hundred boxes $21.50



5¼" DISKETTES WITH LIBRARY CASE

$26.50

Your Choice
SCOTCH
MEMOREX
VERBATIM

	Soft Sector	10 Sector	16 Sector	
SCOTCH	744-0	744-10	744-16	$26.50
MEMOREX	3401	3403	3405	26.50
VERBATIM	525-01	525-10	NA	26.50
DYSAN	104/1	107/1	NA	39.50

Single Side Double Density

DYSAN	104/1D	107/1D	NA	45.00

Double Side Double Density

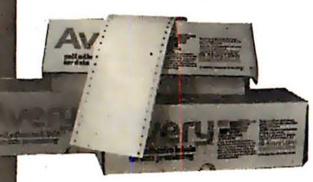
SCOTCH	745-0	745-10	745-16	42.50
DYSAN	104/20	107/20	NA	49.50
DYSAN 96	204/20	NA	NA	59.50

EIGHT INCH DISKETTES

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MEMOREX	3060	29.50
DYSAN	3740/1	39.50
Thirty Two Sector		
SCOTCH	740-32	29.50

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SCOTCH	741-0	39.00
MEMOREX	3090	35.00
DYSAN	3740/D	57.50
Double side Double Density		
SCOTCH	743-0	47.50
MEMOREX	3114	39.50
DYSAN	3740/2D	65.00

Scotch Head Cleaning Kits 5¼ & 8"	$24.95
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United States Post Office approved. 5000 labels per box. 3.5" by 15/16". AVY-4013 6 lbs. Also available: three across (AVY-4031) and removable piggyback (AVY-4097).

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$49

Manufactured by Datapower by use by Diablo in the Hytype daisy wheel printer. Triple outputs, 5 V. 3 Amp; 12 V 3 Amp; -12 V 1 Amp. Input 117/230v. DPR-15A 6 lbs.

MEMORY

2716 EPROM	64K DYNAMIC
4.50	6.95
450ns	4164 200ns
16K STATIC	**16K DYNAMIC**
7.00	1.95
6116 200ns	4116 200ns



2732 EPROM SALE $7.95

DYNAMIC MEMORY

	1-31	32+	100+
4116-150ns 16k	1.95	1.85	1.75
4116-200ns 16k	1.75	1.65	1.50
4164-150ns 64k Japan 128 refresh	8.95	8.25	7.90
4164-150ns 64k Texas Inst. 256refresh	7.00	6.65	6.25
4164-200ns 64k Japan 128 refresh	8.50	7.75	7.50
41256-200 256K dynamic memory	call for pricing		

STATIC MEMORY

21L02-200ns 1k	1.49	1.29	1.15
21L02-450ns 1k	1.29	1.15	.99
2112-450ns 2k	3.95	3.50	3.25
214-300ns 4k			
2114-450ns 4k			
4044-250ns 4k			
4044-450ns 4k			
5257-300ns 4k			
6116-P3 150ns 16k 24 pin	7.50	7.25	6.90
6116-P4 200ns 16k 24 pin	7.00	6.75	6.65
6167 / 2167 100ns 16k 20 pin	9.95	9.50	8.90

EPROMS

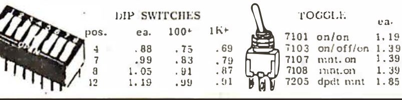
1702-450ns 2K			
2708-450ns 8k	3.50	2.95	2.75
2716-450ns 16k	4.50	4.15	3.75
2716TMS-450ns 16k tri-voltage	7.95	7.65	7.25
2516-450ns 16k	6.95	5.95	5.45
2732-350ns 16k	8.50	8.00	7.60
2732-450ns 16k	6.95	6.65	6.35
2532-450ns 16k	10.50	9.90	9.50
2764-450ns 64k	14.95	13.75	12.50
27128-450ns 128k	call for pricing		



ISO-BAR Noise Filter $49.95

Eight receptacle GSC/Isobar noise filter and surge suppressor reduces problems caused to your computer by electric motors and noisy power lines. GSC-BR 2 lbs

SWITCHES



DIP SWITCHES

pos.	ea.	100+	1K+
4	.88	.75	.69
7	.99	.83	.79
8	1.05	.91	.87
12	1.19	.99	.91

TOGGLE

		ea.	100+
7101	on/on	1.19	.98
7103	on/off/on	1.39	1.19
7107	mnt. on	1.39	1.19
7108	mnt.on	1.39	1.19
7205	dpdt mnt	1.85	1.65

CONNECTORS



GOLD EDGE CONNECTORS

S-100 .125" centers	each	10+
Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Sullins Hi-Rel. .250"	4.50	4.00
Sullins Hi-Rel. W/W	5.35	4.90
Sullins / Altair .140"	4.95	4.50
.156" Centers (standard)		
22/44 Kim Eyelet	2.50	2.15
36/72 Digital Group S/T	5.95	5.50
36/72 Digital Group W/W	6.60	6.15
43/86 Motorola 6800 S/T	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile each	Low Profile 100+	Wire Wrap each	Wire Wrap 100+
8 pin	$.10	$.09	$.46	$.41
14 pin	.10	.09	.45	.41
16 pin	.12	.11	.50	.45
18 pin	.15	.13	.68	.61
24 pin	.26	.24	.94	.87
40 pin	.42	.40	1.60	1.47

"D" Type	each	10-24	25+
DE9P male	$1.60	$1.40	$1.30
DE9S female	2.25	2.00	1.90
DE hood	1.50	1.35	1.20
DA15P male	2.35	2.15	2.00
DA15S female	3.25	3.10	2.90
DA hood 2/P	1.60	1.35	1.30
DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
DB hood 2/P	1.35	1.15	1.05
DC37P male	4.20	4.00	3.70
DC37S female	6.00	5.75	5.50
DC hood 2/P	2.25	2.00	1.75
DD50P male	5.50	5.10	4.75
DD50S female	9.40	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10
CENTRONICS			
57-30360	7.95	6.75	5.75
RIBBON CABLE CONNECTORS			
17/34 5" disk	4.85	4.15	3.95
20/40 TRS-80	5.65	5.05	4.70
25/50 8" disk	5.90	5.15	4.90



NEW OLIVETTI 801 Eight Inch Disk Drive $295

		ONE	TWO	TEN
★ OLIVETTI 801	single	$319	309	295
★ OLIVETTI 802/851	double	425	419	410
SHUGART 801/R	single	395	385	375
SHUGART 851/R	double	525	495	475
QUME DATA TRACK 8	double	525	495	475

★ The 8" Olivetti drives are aprox. ½" wider than the Shugarts.

Five Inch Disk Drives				
OLIVETTI 501/400	single	199	185	175
OLIVETTI 502/451	double	235	225	215

Upon request, all drives are supplied with power connectors and one manual per order.

230 volt 50Hz. 8" add $50.00 per drive.



$995 Eight Inch Subsystem

Two Olivetti 801 disk drives with power supply, 4" exhaust fan complete in dual enclosure with all necessary power cables. Documentation Included. 50 Lbs. CAL-2801

Signal cable add $35.00 WCA-650D

Same as above but with:

Shugart 801R	MSD2801	$1195
Shugart 851R	MSD2851	1450
Olivetti 802	CAL2802	$1250
Qume DT8	MSD8DT	1450

SPECIAL $895

Volumn Pricing Upon Request

Seagate Compatable 7.5 MEGABYTE Winchester Hard Disk Drive

We have priced this so low that the manufacturer has asked not to use their brand name in our advertising.

Industry standard Seagate plug compatable. Drive fits into the same space as a 5¼" floppy disk drive. CAL-561/2

CONRAC MONITOR

Nine Inch $59

Requires separate horizontal and vertical sync. Single 12 volt supply. Factory new surplus. Composite video adaptor available ($15) CON-BW9 8 lbs.



All merchandise sold by California Digital is premium grade. Shipping: First five pounds $3.00. Each additional $.50. Foreign orders: 10% shipping. Excess will be refunded. California residents add 6½% sales tax. COD's discouraged. Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet. Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

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TECHNICAL & CALIFORNIA
(213) 679-9001

California Digital

Post Office Box 3097 B • Torrance, California 90503



HEATH KIT H17 SUB-SYSTEM

$239

The H-17 is the same unit you have seen advertised in the Heath Kit catalog for $695. Plugs directly into your Z8 or Z89 computer. Unit contains 117/230v. power supply and one Perkin-Elmer/Wangco 5¼" floppy disk drive. Seven milisecond track to track time on the floppy disk drive. Limited supply. HTH-H17 35 lbs.

SHUGART SA·4004

$995



14 Megabyte Shugart SA4004 hard disk drive. Current Shugart single unit price on this drive is $2475. Each is shipped in factory sealed container. SHU-4004 35 lbs.

MICROSWITCH ASCII KEYBOARD



HALL EFFECT 81 KEYS **$79**

This Honeywell Microswitch keyboard has been recently purchased from the CRT division of Lear Seigler. Each keyboard contains 81 high reliability Hall Effect keys. Outputs seven bit parallel ASCII along with strobe. MIC-81SD5 3 lbs.

DEC Q-Buss

$59

Four Slot Backplane Assembly



Four slot dual height. This is the same backplane used with the Digital Equipment Corp PDP-11/23 computer. Current DEC replacement price on this unit is $157. Each assembly is factory new and sold with a 90-day warranty. DEC-H9.281 3 lbs.

PRINTERS



MATRIX PRINTERS

Okidata 82A serial & parallel 9.5" paper OKI-82A	459.00
Okidata 83A serial & parallel 15" paper OKI-83A	695.00
Okidata 84A parallel only 15" paper OKI-84AP	1.079.00
Okidata 84A serial & parallel 15" paper OKI-84AS	1,219.00
Epson MX80 with graphics and tractor feed EPS-MX80	419.00
Epson MX80FT with graphics, friction & tractor feed EPS-MX80FT	539.00
Epson MX100 with graphics. 15" paper EPS-MX100	695.00
NEC 8023A parallel 9.5" paper, graphics NEC-8023A	48900
Anadex 9500A high speed dot matrix printer 15" ADX-9500A	1.279.00
Anadex 9501A 15" paper with graphics ADX-9501A	1.279.00
Texas Instruments 810 serial 15" upper & lower case TEX-810L	1.299.00
Datasouth DS180 high speed 180 char/sec. 15" DSI-180	1.295.00
Prowriter 8510 parallel 9.5" PRO-8510P	49500
Prowriter 8510 serial 9.5" PRO-8510S	639.00
Prowriter II 15" paper PRO-2P	750.00
Printronix P300 high speed printer 300 lines/min PTX-P300	4.500.00
Printronix P600 high speed printer 600 lines/min PTX-P600	6.150.00
IDS prism 80 column, graphics, (non-color) IDS-P80G	1.150.00
IDS prism 132 COLOR with graphics 15" paper IDS-P132CG	1,65000
Mannesmann Tally 1805 200 cps serial MAN-1805	1.650.00

WORD PROCESSING PRINTERS

NEC7710 55 char/sec thimble, serial only NEC-7710	2.37900
NEC7730 same as above parallel only NEC-7730	2.379.00
NEC3510 serial 15" NEC-3510	1.775.00
Diablo 620R101 25 cps serial DBL-620	1.270.00
Diablo 630 40cps serial DDL-630	2,250.00
Smith Corona TP-1 daisy wheel parallel SCMTP1P	659.00
Smith Corona TP-1 daisy wheel serial SCM-TP1S	659.00
Brother HR11 daisy wheel printer parallel BTH-HR1P	855.00
Brother HR11 serial interface BTH-HR1S	895.00
Diablo630 DBL-630	2.095.00
Starwriter F10 serial PRO-F10S	1.475.00
Starwriter F10 parallel PRO-F10P	1.475.00

MONITORS

Zenith Z121 green phosphor 12" 40/80column switch ZTH-Z121	115.00
BMC 12A green phosphor 15 Mhz. composit video BMC-12A	88.00
BMC 12EN green phosphor 20 Mhz. high resolution BMC-12EN	13900
NEC JB1201 green phosphor 18 Mhz composit video NEC-JB1201	169.00
NEC JB1260 green phosphor commercial grade composit NEC-1260	129.00
Motorola 23" open frame blk/white composit video MOT-BW23	159.00
Motorola 12" open frame blk/white reqires horz sync & powMOT-BW12	69.00
Conrac 9" open frame requires horz. sync & power supply CON-BW9	59.00
(COLOR)	
NEC JC1201 composit color NEC-JC1201	325.00
NEC RGB monitor NEC-12020M	875.00
BMC 13" Composit video BMC-1400CL	273.00
BMC 13" RGB color monitor BMC-1401RGB	329.00
BMC interface card for Apple II for above RGB BMC-81RGB	14900
Comrex/Hitachi 13" RGB high res. monitor COM-6600	539.00
Comrex/Hitachi 13" Composit color monitor COM-6500	395.00
Amdek color #1 composit video AMD-100	349.00
Amdek color #2 high res. RGB color monitor AMD-200	739.00
Amdek color #3 commercial grade color RGB AMD-300	475.00



Direct Connect MODEMS

Hayes Micromodem 100 S-100 modem HYS-100	319.00
Hayes Smart Model RS232 HYS-232	229.00
Hayes Micromodem II Apple direct connect HYS-MM2	279.00
Hayes Chronograph time & date HYS-CHR232	19900
Novation Cat acoustic connect NOV-CAT	14900
Novation D Cat direct connect via handset NOV-DCAT	16900
Novation 212 Autocat Bell 212A NOV-212	595.00
Novation Auto Cat 103 NOV-AUTO	219.00
Universal 103LP direct connect, line powered UDS-103LP	169.00
Universal 103LPJ direct connect, auto answer UDS-103LPJ	209.00
Universal 202 direct connect 1200 baud, half duplex UDS-202LP	189.00
Universal 212LP direct connect 1200 baud, full duplex UDS-212LP	45000
Signalman Mark I direct connect with terminal cableSGL-MK1	89.00

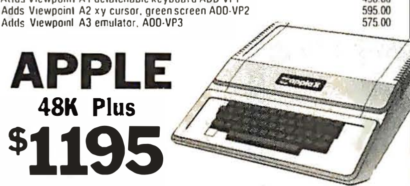
TERMINALS



Ampex Dialogue 80 green screen, two page, function keys APX-D80C	79500
Ampex Dialogue 80 amber screen, two page, function keys APX-D80A	79500
Ampex Dialogue 80 green screen, Selectric keyboard APX-D81G	895.00
Ampex Dialogue 81 amber screen. Selectric keyboard APX-D81A	895.00
Ampex Touch Term screen command for data entry APX-T80	
Wyse horz & vert split screen, metal case, detatch keybd. WYS-100	82500
Televideo 910C emulator TVI-910C	595.00
Televideo 910 Plus block mode TVI-910P	59500
Televideo 925C detatchable keyboard. 22 function keys TVI-925	795.00
Televideo 950 graphic char., split screen, 22 functions TVI-950	98500
IBM 3101-10 detatchable keyboard, green IBM-3101	1,19500
Zenith Z-19 detatchable keyboardZTH-Z19	76500
Adds Viewpoint A1 detatchable keyboard ADD-VP1	498.00
Adds Viewpoint A2 xy cursor, green screen ADD-VP2	595.00
Adds Viewpoint A3 emulator, ADD-VP3	575.00

APPLE 48K Plus

$1195



APPLE BRAND PRODUCTS

APL-48P	Apple Plus 48K RAM	1.195.00
APL-DSK1	Apple disk with controller card	560.00
APL-DSK2	Apple disk without controller card	49500

XITEN

XTN-G10	Xiten 10 Megabyte Gallium hard disk	1.99500
XTN-16K	16K RAM card for Apple II	6900

RANA SYSTEMS

RAN-APL1	Apple add on disk drive with controller	525.00
RAN-APL2	Apple add on drive without controller	395.00

CALIFORNIA COMPUTER SYSTEMS

CCS-7710	Asynchronous Serial Interface	12500
CCS-7728	Centronics Parallel Interface	9500
CCS-7720	Apple Parallel Interface	9500
CCS-7114	12K Rom/Prom Module	115.00
CCS-7424	Calendar/Clock Module	95.00
CCS-7440	Programmable Timer	9500
CCS-7811B	Arithmetic Processor for AppleII plus	31900

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MTN-CPS	CPS Multifunction Card	169.00
MTN-TCLK	Clock/Calendar	119.00
MTN-STLK	Supertalker SD200	14900
MTN-ROMF	Rom Plus with Keyboard filter	16900
MTN-ROMRTR	Rom Writer with Eprom socket	145.00
MTN-ADDA	A•D/D•A Converter	28900
MTN-BSR	X-10 Control Card for BSR system	14900

MICRO SOFT

MSF-SFTCRD	Microsoft Z-80CPU card	249.00
MSF-16KRAM	Microsoft 16K RAM card	125.00

VISTA

VSA-A800	Vista 8" controller card	48900
VSA-VIS80	Vista Vision 80	28900
MCI-CNTRL	Micro Sci disk drive controller	89.00

FOURTH DIMENSION

FDN-SPRDRV	Super Drive-35 track Apple add on	329.00

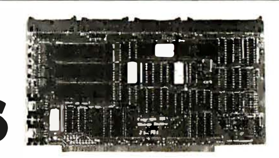
SORRENTO VALLEY ASSOC

SVA-221	Single sided, single density controller	360.00
SVA-222	Double sided, single density controller	36000
SVA-223	Single or double sided, double density	475.00

ADVANCED BUSINESS TECH

ABT-13KEYN	13-Key pad for new Apple	95.00

S-100 BOARDS



16 BIT MICROPROCESSORS

GBT-8687	Godbout 8086/8087Microprocessor board	495.00
GBT-8687	Godbout 8088/8085 dual 8 bit microprocessor	359.00
SEA-8086	Seattle Computer 16 bit microtwo board set	669.00
TEC-8086	TecmarComputer 16 bit microprocessor	59500
LOM-8086	LomasData Systems LightingOne	call

SINGLE BOARD COMPUTERS

WAV-BLT1	WavemateBullet 1 with floppy, 256K (not S-100)	79500
AMD-Z80	Advanced Micro Digital, floppy & 64K	75000
TEL-FDC1	Teletek FDC1 Single board NEC765 controller	67500

8 BIT MICROPROCESSORS

GBT-Z80	Godbout Z80 8 bitCPU24 bit extended address	25000
CCS-2810	CaliforniaComputer Z-80microprocessor	27500
SDS-SBC200	SD Systems SBC-200 Z-80 microprocessor	27500
MSM-Z80	Measurement System Z-80 2810 microprocessor	425.00
TAR-Z80	Tarbell Electronics Z-80 with two RS232 ports	395.00

FLOPPY DISK CONTROLLERS

GBT-DSK1	Godbout DiskOne double densityNEC-765	39500
MDS-DJ2	MorrowDesigns DiskJockeyIIwith CPM	35000
MDS-DJ1	Morrow DesignsDisk Jockey I single density	22500
CCS-2422	California Computer 2422 withCPM	33900
TAR-DDC	Tarbell Electronics double density controller	41900
TAR-SDC	TarbellElectronicssingle density controller	27900

CPM OPERATING SYSTEM

GBT-CPM22	Godbout CPM 2.2 for Disk One 8 bit operation	160.00
GBT-CPM86D	Godbout CPM 86 for Disk One for use with 8086	26500
GBT-CPM86	Godbout CPM 86 for operation with 8086 board	26500

HARD DISK CONTROLLER

GBT-DSK2	Godbout Disk II hard disk controller	695.00
GBT-DSK3	Godbout Disk III hard disk controller	
MDS-W506	MorrowDesignsWinchester for Seagate 506	49500
WDI-1000	Western DigitalWD-1000 (notS-100)	49500

EPROM BOARDS

ADS-PB100	Ackerman Digital Prom Blaster 100	27500
SDS-P100	SD Systems Prom-100 programmer	26000
SSM-PB1	SSMProm prgrammer up to 2716	19500
DGR-P32	Digital Research 32K Eprom read only board	10500

STATIC MEMORY BOARDS

CAL-S64	CaliforniaDigitalStatic 64 8/16 bit (6167)	595.00
GBT-R16	Godbout Ram 16 64K memory 8/16bit	760.00
GBT-R17	Godbout Ram 17 64K memory 8 bit 24bit add	395.00
GBT-R20	Godbout Ram 20 32k static memory 4K bound	375.00
GBT-R21	Godbout Ram21 128K 8/16 bit static memory	995.00
CCS-2116	California Comuter 2116 16K static memory	335.00

DYNAMIC MEMORY BOARDS

CAL-D256	California Digital 256K dynamic memory 8 bit	495.00
SDS-EX3	SDSystemsExpandoramIII256K dynamic	795.00
CCS-2065	CaliforniaComputers 2065 64K dynamic	395.00
MSM-DMB64	Measurement Systems DMB6400 (Alpha Micro)	595.00

INTERFACE BOARDS

MDS-SW1	Morrow Designs Switchboard 2 serial/ 4 parallel	239.00
MDS-MTL1	Morrow Designs Multiboard 3 serial/ 2 parallel	275.00
GBT-133A	Godbout Interfacer I, 2 serialports	199.00
GBT-150A	Godbout Interfacer II, 1 serial/3 parallel	199.00
GBT-135A	Godbout Interfacer III, with 5 serial ports	495.00
GBT-138A	Godbout Interfacer III, with 8 serial ports	585.00
GBT-187A	Godbout Interfacer IV 3 serial/2 parallel	295.00
CCS-2710	CaliforniaComputer 4portserialinterface	295.00
CCS-2720	CaliforniaComputer 2 serial / 2 parallel	295.00
CCS-2720	California Computer 4 port parallel	219.00

SPECIAL FUNCTION BOARDS

HYS-M100	D.C. Hayes Micromodem S-100FCC approved	325.00
ADS-N100	Ackerman Digital Noisemaker with Vortrax module	119.00
DTC-CC100	QT Computer clockcalendar board	135.00
SCN-M100	Scion Microangelo graphics, monochrome	965.00
GBT-SPC1	GodboutSpectrum 100 color videoboard	399.00
TEC-AD212	Tecmar A/D 12bit accuracy, 16 channel	485.00
GBT-SYS1	Godbout System support board	350.00
GBT-SYS9511	Godbout SystemSupport with 8231/ 9511 mathchip	539.00
MUL-TB1	Mullins extender board with test probe	79.00
MUL-ICB10	Mullins Opto-Isolatorcontrols 8 channels	179.00
ADS-KG100	Ackerman DigitalKluge prototype board	149.00
IOT-W100	I/O Technology wire wrapprototype board	49.00
ART-WW100	Artec Electronics Wire wrap proto board	25.00
ART-GP100	Artec Electronics General purpose solder	25.00
CAL-MB18	California Digital 18 slot motherboard	35.00

OCR READER

OPTICAL RECOGNITION EQUIPMENT



$295

DISPLAYED ASCII OUTPUT

WAND TEST DOCUMENT
4013016-001 REV. A

This optical recognition reader is the same unit currently used at the check out register at your local Sears, Roebuck or J. C. Penney store.

These units can be used for inputing data for inventory control or recording information from returned invoices, checks and other documents.

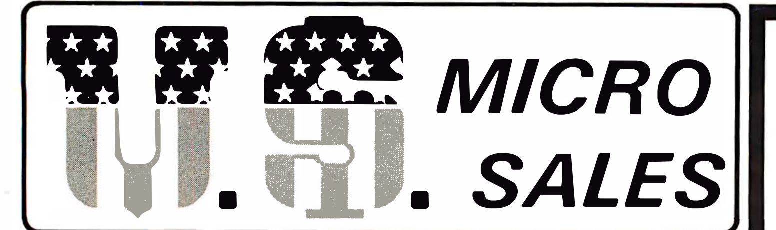
Interfaces 8 bit ASCII parallel with "handshaking". Documentation and application notes included.

Each unit is brand new in factory sealed container. Original acquisition of this reader is approximately $2,500. ORE-720 15 lbs.



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Shipping: First five pounds $3.00. Each additional $.50.
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California residents add 6½% sales tax. COD's discouraged.
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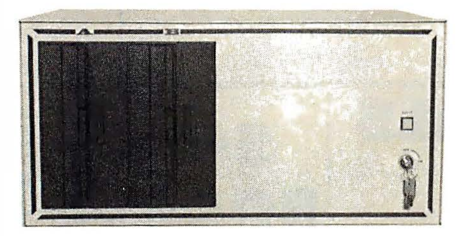


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$39.95

★ S-100 SYSTEMS ★

S-100-12

Complete 12 Slot 3 board computer with Z-80 CPU, 64K DynamicRam, Floppy Disk Controller and Disk Drives including CP/M*.



With 2 801 Shugart	$2250.00
With 2 851Shugart	2500.00
With 2 Qume DT8	2450.00
Less Drives and CP/M*	1350.00
Cabinet Only	250.00

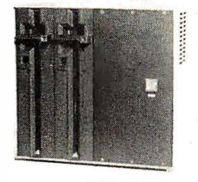
All of the above include Drive Mount Plate Plus AC and DC Cables. Some assembly required.

CP/M is a Trademark of Digital Research

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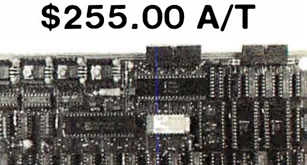
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- Includes CP/M*

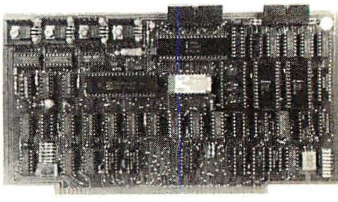


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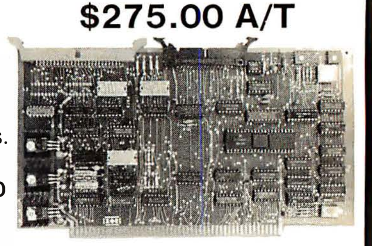




2 Serial/3 Parallel Ports
On board 2716 PROM
Z-80 CTC Optional
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Memory Management A16 - A17
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With WD-1795 Chip Set.
SS/DD 5" or 8" up to 4 Drives.

Dual 50 Data Cable - **$35.00**

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+5 @ 4A ● +24V @ 3A ● −5V @ 1A



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With 2 851R Shugart	1225.00

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With 2 QUME DT8	1195.00
With 4 Tandon TM848-1	1995.00

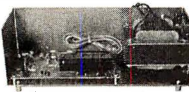
CABINET With Power Supply



for MINI 5" or WINCHESTER 5"
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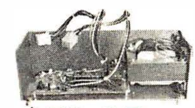
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With 2 SA 400 Shugart	595.00
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For 2 8" or 5" Shugart 801R or 851R, Qume DT-8 with DC cables for 8"
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+16V @ 6A
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PC Board Design
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$12.50
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S-100-8

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FORTRAN 80 ....$400.00
COBOL 80 ....$600.00
MACRO 80 ....$165.00
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PASCAL/M $320.00
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SSS FORTRAN $215.00
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ZENITH VIDEO MONITOR—
ZVM $145.00
AMDEK MONITORS—
AMDEK Color 1 ....$399.00
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- Qume DT-8's $540.00
- SA 400 ....$230.00
- SA 450 ....$340.00
- SA 410 SS 96 TPI $375.00
- SA 460 DS 96 TPI $425.00
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- TM 100-2 ....$340.00
- TM 100-3 ....$375.00
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7400

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SN7401N	14	.19
SN7402N	14	.25
SN7403N	14	.25
SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.29
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.35
SN7413N	14	.35
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.35
SN7422N	14	.45
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.49
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	.99
SN7444N	16	.99
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459A	14	.25
SN7460N	14	.19
SN7470N	14	.29

Part No.	**Pins	Price
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN4576N	16	.35
SN7479N	14	4.95
SN7480N	14	.69
SN7482N	14	1.19
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.59
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.69
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	2.75
SN74100N	24	1.49
SN74104N	14	.89
SN74105N	14	.89
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.55
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.69
SN74142N	16	2.95
SN74143N	24	2.95
SN74144N	24	2.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59

Part No.	**Pins	Price
SN74156N	14	.59
SN74157N	16	.59
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.79
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN75177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	.89
SN74184N	16	1.95
SN74185N	16	1.95
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	1.95
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

74LS00	14	.25
74LS01	14	.25
74LS02	14	.25
74LS03	14	.25
74LS04	14	.29
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.35
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.39
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.69
74LS86	14	.39
74LS90	14	.55

74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.49
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.59
74LS139	14	.59
74LS151	16	.59
74LS153	16	.59
74LS154	24	.99
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.59
74LS175	16	.59
74LS181	24	2.49
74LS190	16	.89
74LS191	16	.89

74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.09
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.29
74LS374	20	1.29
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55

74S124	16	2.95
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	14	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	.99
74S175	16	.99
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49

74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	.79
74S280	14	1.95
74S287*	16	1.95
74S288*	16	1.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
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CA3059N	14	3.25

CA3060N	16	3.25
CA3080H		1.25
CA3081N	16	1.49
CA3082N	16	1.49
CA3083N	16	1.49
CA3086N	14	.69

CA3089N	16	1.69
CA3096N	16	1.19
CA3130H		1.95
CA3140H		1.49
CA3160H		1.95
CA3401N	14	.59
CA3600N	14	3.95

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CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4009	16	.39
CD4010	16	.39
CD4011	14	.29
CD4012	14	.15
CD4013	14	.39
CD4014	16	.79
CD4015	16	.39
CD4016	14	.39
CD4017	16	.75
CD4018	16	.79
CD4019	16	.39
CD4020	16	.75
CD4021	16	.79
CD4022	16	.79
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.95
CD4035	16	.89

CD4040	16	.79
CD4041	14	.79
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.39
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.79
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CD4056	16	2.95
CD4059	24	7.95
CD4060	16	.89
CD4066	14	.39
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.79
CD4078	14	.49
CD4081	14	.29
CD4082	14	.29
CD4093	14	.49

CD4098	16	1.95
CD4506	16	1.19
CD4507	14	.39
CD4508	24	3.95
CD4510	16	.89
CD4511	16	.89
CD4512	16	.89
CD4514	24	1.79
CD4515	24	1.79
CD4516	16	.99
CD4518	16	.99
CD4519	16	.39
CD4520	16	.79
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.19
CD4543	16	1.19
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.75
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

MICROPROCESSOR COMPONENTS

STATIC RAMS

Part No.	**Pins			Price
1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	2.49
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.95
2112	16	256x4	(450ns) MOS	2.95
2114	18	1024x4	(450ns)	2.25 — 8/14.95
2114L	18	1024x4	(450ns) L.P.	2.49 — 8/16.95
2114-2	18	1024x4	(200ns)	2.49 — 8/16.95
2114L-2	18	1024x4	(200ns) L.P.	2.95 — 8/19.95
2141-3	18	4096x1	(150ns)	3.95
2147	18	4096x1	(70ns)	4.95
2148	18	1024x4	(70ns)	8.95
TMS4044	18	4096x1	(450ns)	3.95
TMS4045	18	1024x4	(450ns)	3.95
5101	22	256x4	(450ns) CMOS	4.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116-4	24	2048x8	(200ns) CMOS	7.95
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	8.95
7489	16	16x4	(50ns) 3101	2.25
74C920	22	256x4	(250ns) CMOS (6551)	3.95
74C921	18	256x4	(250ns) CMOS	3.95
74C929	16	1024x1	(250ns) CMOS (6501)	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	3.95
74S189	16	16x4	(35ns) 93405	1.95
74S200	16	256x1	(80ns) 93410	3.95
74S206	16	256x1	(60ns) 93411	3.95
74S289	16	16x4	(35ns) 3101	2.25
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

EPROMS

1702A	24	256x8	(1us)	4.95
2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	2.95
TMS2516	24	2048x8	(450ns) 2716	6.95
TMS2532	24	4096x8	(450ns) NMC2532	9.95
TMS2564	28	8192x8	(450ns)	29.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	5.95
2732	24	4096x8	(450ns)	9.95
27580	24	1024x8	(450ns) single +5V	2.95
MM2764	28	8192x8	(450ns)	29.95

MICROPROCESSOR CHIPS

Z80 (780C)	40	CPU (MK3880N) (2MHz)	5.95
Z80A (780-1)	40	CPU (MK3880N-4) (4MHz)	6.95
CDP1802	40	CPU	9.95
2650	40	MPU	14.95
IDM2901ADC	40	CPU—4-bit slice (Com. Temp. Gr.)	19.95
MCS6502	40	MPU w/Clock (65K bytes mem.)	9.95
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INS8039N-6	40	CPU-Sgl. chip 8-bit (128 bts. Ram)	6.95
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INS8073N	40	CPU w/Basic Micro Interpreter	24.95
P8085	40	CPU	5.95
TMS9900JL	64	MPU — 16-bit	39.95

MICROPROCESSOR MANUALS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

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MC6800	40	MPU	4.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6810API	24	128x8 Static RAM	3.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	4.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	10.95
MC6850	24	Asynchronous Comm. Adapter	4.95
MC6852	24	Synchronous Serial Data Adapter	5.75
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MC6862	24	2400bps Modulator	12.95
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8080/8080A SUPPORT DEVICES

INS8080A	40	CPU	3.95
DP8212	24	8-bit Input/Output	2.25
DP8214	24	Priority Interrupt Control	3.95
DP8216	16	Bi-Directional Bus Driver	2.25
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Controller/Bus Driver	3.49
DP8238	28	System Controller	4.49
INS8243	24	I/O Expander for 48 Series	5.95
INS8250	40	Asynchronous Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	7.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	System Timing Element	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.49
DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
DP8310	20	Octal Latched Peripheral Driver	4.95
DP8311	20	Octal Latched Peripheral Driver	4.95

DYNAMIC RAMS

Part No.	**Pins			Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	2.49
4116N-2	16	16,384x1	(150ns)	2.25 — 8/16.95
4116N-3	16	16,384x1	(200ns)	1.95 — 8/14.95
4116N-4	16	16,384x1	(250ns)	1.49 — 8/10.95
4164N-2	16	65,536x1	(200ns)	9.95
MM5261	18	1024x1	(300ns)	.49 — 8/1.95
MM5262	22	2048x1	(365ns)	.49 — 8/1.95
MM5270	18	4096x1	(250ns) MK4096	2.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5290-2	16	16,384x1	(150ns)	2.25 — 8/16.95
MM5290-3	16	16,384x1	(200ns)	1.95 — 8/14.95
MM5290-4	16	16,384x1	(250ns)	1.49 — 8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

PROMS

74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S478	24	1024x8	PROM T.S. (TBP28S86)	8.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	3.95
82S129	16	256x4	PROM T.S. (27S21)	3.95
82S130	16	512x4	PROM O.C. (27S12)	5.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4	PROM O.C. (82S190)	19.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	19.95

ROM'S

2513 (2140)	24	Character Generator (Upper Case)	9.95
2513 (3021)	24	Character Generator (Lower Case)	9.95

NMOS READ ONLY MEMORIES

MCM66710P	24	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	24	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	24	128x9x7 Alpha. Control Char. Gen.	13.50

DATA ACQUISITION

DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	2.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.95
AF100-1CN	16	Universal Active Filter 2.5%	5.95
AF121-1CJ	24	Touch Tone Low Band Filter	19.95
AF122-1CJ	24	Touch Tone High Band Filter	19.95
LM308CH		Super Gain Op Amp	1.15
LM334Z		Constant Current Source	1.30
LM335Z		Temperature Transducer	1.40
LF356N	8	JFET Input Op Amp	1.10
LF398N	8	Sample & Hold Amplifiers	3.95
LM399H		Temp.Comp. Prec. Ref. (.5ppm/C°)	5.00
ADC0804	20	8-bit A/D Converter (1 LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	7.95
DAC1020	16	10-bit D/A Converter (0.05% Lin.)	8.49
DAC1022	16	10-bit D/A Converter (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Converter (0.20% Lin.)	6.95
CD4051N	10	8-Channel Multiplexer	.79
AY-5-1013	40	30K BAUD UART	3.95

SPECIAL FUNCTION

DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	40	Floppy Disk Controller	16.95
INS2651N	28	Communication Chip	8.95
MM58167N	24	Microprocessor Real Time Clock	8.95
MM58174N	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg. VAC Fluor. Drvr. (20-pin pkg.)	3.25

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AY-5-9100	18	Push Button Telephone Dialer	14.95
AY-5-9200	16	Repertory Dialer	14.95
AY-5-9500	14	CMOS Clock Generator	4.95
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HD0165-5	24	Keyboard Encoder (16 keys)	9.95
74C922	18	Keyboard Encoder (16 keys)	4.49
74C923	20	Keyboard Encoder (20 keys)	4.95
MM53130N	18	Touch Tone Dialer	5.95
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Part No.	Description	Price
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DB25S	SOCKET (RS232)	3.50
DB25PF-179	PLUG (RS232) Wire Wrap style	4.95
DB51226-1	CABLE COVER for DB25P or DB25S	1.75
DB25P-831	PLUG — Right Angle — PC Mount	4.95
DB25S-831	SOCKET — Right Angle — PC Mount	5.25
D20418-2	Screw Lock for DB25 Series Connectors (Locks connector to panel)	2/.99

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Part No.	Contacts	Sp.	Description	Price
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18/36SE	18/36	.156	Solder Eyelet	2.49
22/44SE	22/44	.156	Solder Eyelet	2.95
22/44PC	22/44	.156	PC type (no mtg. ears)	1.49
50/100SE	50/100	.125	Solder Eyelet	9.95
22/44WW	22/44	.156	Wire Wrap - Level 3	7.95
67031-5	22/44	.156	WW (Pns.0625x.03x.75)	3.95
R681-1	50/100	.125	Wire Wrap - Level 3	12.95
R681-2	50/100	.125	Wire Wrap - Level 3	12.95

IC SOCKETS

For Socket Required, See Column After The IC Part No.

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

— Soldertail Standard Tin & Gold Also Available —

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10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
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INTERSIL

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7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	16.95
7117CPL	40	3½ Digit A/D LED Dis. HLD.	15.95
72D1IUS		Low Battery Volt Indicator	2.25
72051PG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
72081PI	28	Seven Decade Counter	15.95
72091PA	8	Clock Generator	3.95
72151PG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216CIJI	28	8 Digit Freq. Counter C.A.	24.95
721601PI	28	8 Digit Freq. Counter C.C.	19.95
72171JI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	14.95
72241PL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AIJL	40	8 Digit Univ. Counter	29.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95
72401JE	16	CMOS Bin Prog. Timer/Counter	4.95
72421JA	8	CMOS Divide-by-256 RC Timer	2.25
72501JE	16	CMOS BCD Prog. Timer/Counter	6.00
72601JE	16	CMOS BCD Prog. Timer/Counter	5.25
75551PA	8	CMOS 555 Timer	1.45
75561PD	14	CMOS 556 Timer	2.20
76118CPA	8	CMOS Op Amp Comparator 5MV	2.25
76128CPA	8	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	8	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	16	CMOS Tri Op Amp Comp. 10MV	6.35
7641CCPD	14	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	14	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	8	Voltage Converter	2.95
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74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
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74C85	16	1.95
74C86	14	.39
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74C90	14	1.19
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74C107	14	.89
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74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	.79
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
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LM340K-12		1.35
LM340K-15		1.35

LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM341P-5		.75
LM341P-12		.75
LM341P-15		.75
LM342P-5		.69
LM342P-12		.69
LM342P-15		.69
LM348N	14	.99
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47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
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.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

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1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
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2200/16V	.89	.79	.69	470/25V	.35	.31	.27

Circle 252 on inquiry card.

Circle 252 on Inquiry card.

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PRA-27082 *Apple cable* **$19.95**
PRA-27087 *TRS-80 cable* **$24.95**
PRA-43081 *2K hi speed serial card* **$99.95**
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8023 DOT MATRIX - NEC

100 CPS, proportional spacing, hi-resolution graphics, correspondence quality printing, bi-directional tractor & friction feed.
NEC-8023A *8023 parallel* **$499.95**
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12 CPS daisy wheel printer from Smith Corona.
PRD-45101 *Centronics parallel* **$648.95**
PRD-45102 *RS-232C serial* **$648.95**

LETTER QUALITY PRINTER - Jade

Uses standard daisy wheels and ribbon cartridges, 16 CPS bi-directional printing, semi-automatic paper loader (single sheet or fan fold), 10/12/15 pitch, up to 16" paper, built-in noise suppression cover.
PRD-11001 *Centronics parallel* **$899.95**
PRD-11002 *RS-232C serial model* **$969.95**
PRA-11000 *Tractor Option* **$169.95**

STARWRITER F-10 - C. Itoh

New 40 CPS daisy wheel printer with full 15" carriage, uses standard Diablo print wheels and ribbons, both parallel and serial interfaces included.
PRD-22010 *Starwriter F-10* **$1495.95**

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Desk top printer stand and continuous form paper holder.
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Shugart SA455 *half-size double-sided 48 TPI*
MSM-104550 .... $349.95 ea 2 for **$329.95 ea**

Shugart SA465 *half-size doule-sided 96 TPI*
MSM-104650 .... $399.95 ea 2 for **$379.95 ea**

Tandon TM100-2 *double-sided double-density 48 TPI*
MSM-551002 .... $294.95 ea 2 for **$269.95 ea**

Shugart SA450 *double-sided double-density 35 track*
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Tandon TM100-3 *single-sided double-density 96 TPI*
MSM-551003 .... $294.95 ea 2 for **$269.95 ea**

Tandon TM100-4 *double-sided double-density 96 TPI*
MSM-551004 .... $394.95 ea 2 for **$374.95 ea**

MPI B-51 *single-sided double-density 40 track*
MSM-155100 .... $234.95 ea 2 for **$224.95 ea**

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MSM-155200 .... $344.95 ea 2 for **$334.95 ea**

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MSM-155300 .... $369.95 ea 2 for **$359.95 ea**

MPI B-92 *double-sided double-density 77 track*
MSM-155400 .... $469.95 ea 2 for **$459.95 ea**

5¼" Cabinets with Power Supply
END-000216 *Single cab w/power supply* **$69.95**
END-000226 *Dual cab w/power supply* **$94.95**

8" Disk Drives

Shugart SA810 *half-size single-sided double-density*
MSF-108100 .... $424.95 ea 2 for **$394.95 ea**

Shugart SA860 *half-size double-sided double-density*
MSF-108600 .... $574.95 ea 2 for **$549.95 ea**

Shugart SA801R *single-sided double-density*
MSF-10801R .... $394.95 ea 2 for **$389.95 ea**

Shugart SA851R *double-sided double-density*
MSF-10851R .... $554.95 ea 2 for **$529.95 ea**

Tandon TM848-1 *single-sided double-den thin-line*
MSF-558481 .... $379.95 ea 2 for **$369.95 ea**

Tandon TM848-2 *double-sided double-den thin-line*
MSF-558482 .... $494.95 ea 2 for **$484.95 ea**

Qume DT-8 *double-sided double-density*
MSF-750080 .... $524.95 ea 2 for **$498.95 ea**

Mitsubishi M2894-63 *double-sided double-density*
MSF-289463 .... $494.95 ea 2 for **$474.95 ea**

Siemens FDD 100-8 *single-sided double-density*
MSF-201120 .... $384.95 ea 2 for **$349.95 ea**

Dual Disk Sub-Systems

Disk Sub-Systems - Jade

Handsome metal cabinet with proportionally balanced air flow system, rugged dual drive power supply, power cable kit, power switch, line cord, fuse holder, cooling fan, never-mar rubber feet, all necessary hardware to mount 2-8" disk drives, power supply, and fan, does not include signal cable.

Dual 8" Sub-Assembly Cabinet
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END-000421 *Cabinet kit* **$225.00**
END-000431 *A & T* **$359.95**

8" Sub-Systems - Single Sided, Double Density
END-000423 *Kit w/2 FD100-8Ds* **$975.00**
END-000424 *A & T w/2 FD100-8Ds* **$1175.00**
END-000433 *Kit w/2 SA-801Rs* **$999.95**
END-000434 *A & T w/2 SA-801Rs* **$1195.00**

8" Sub-Systems - Double Sided, Double Density
END-000426 *Kit w/2 DT-8s* **$1224.95**
END-000427 *A & T w/2 DT-8s* **$1424.95**
END-000436 *Kit w/2 SA-851Rs* **$1274.95**
END-000437 *A & T w/2 SA-851Rs* **$1474.95**

Prices may be slightly higher at our retail locations. Please contact the store in your area for exact pricing.

Hard Disk Drives

12 MEGABYTE SUB-SYSTEM - DayStar

12 Megabyte Winchester sub-system for most CP/M based microcomputers including Apple II, S-100, IBM PC, NEC, Xerox, TRS-80 II, Heath H-89, and others. Sub-system includes interface, controller, cabinet, power supply, CP/M software patch, & cables - ready to just plug in and run. A 1 Megabyte back-up drive is also available.
MSH-531010 *S-100 sub-system* **$2095.00**
MSH-531020 *Apple II sub-system* **$2095.00**
MSH-531030 *NEC sub-system* **$2095.00**
MSH-531040 *Xerox sub-system* **$2095.00**
MSH-531050 *TRS-80 II sub-system* **$2095.00**
MSH-531060 *IBM PC sub-system* **$2095.00**
MSH-531099 *1 Megabyte back-up* **$699.95**

12 MEGABYTE WINCHESTER - Tandon

5¼" hard disk drive for hi-speed mass storage.
MSH-550603 *Bare 5¼" drive* **$1094.95**

Jade Bus Probe

THE BUS PROBE - Jade

Inexpensive S-100 Diagnostic Analyzer

So your computer is down. And you don't have an oscilloscope. And you don't have a front panel... You're not alone - most computers have their occasional bad days. But without diagnostic equipment such as an oscilloscope (expensive!) or a front panel (expensive!), it can be very difficult to pinpoint the problem. Even if you have an extender board with a superfast logic probe, you can't see more than one signal at a time. You're stuck, right?

Not anymore; Jade is proud to offer our cost-effective solution to the problems mentioned above: ***THE BUS PROBE.***

Whether you're a hobbyist with a cantankerous kluge or a field technician with an anxious computer owner breathing down your neck, you'll find THE BUS PROBE speeds your repair time remarkably. Just plug in THE BUS PROBE and you'll be able to see all the IEEE S-100 signals in action. THE BUS PROBE allows you to see inputs, outputs, memory reads and writes, instruction fetches, DMA channels, vectored interrupts, 8 or 16 bit wide data transfers, plus the three bus supply voltages.

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TSX-200B *Bare board* **$59.95**
TSX-200K *Kit* **$119.95**
TSX-200A *A&T* **$149.95**

Software

PLANNER CALC - Target Software

Spread sheet (what if ?) program designed with the user in mind, user oriented (simple english) commands allow you to quickly master this powerful software package, supplied on disk for most CP/M based systems.
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SFC-12251050F *SS SD 8" CP/M* **$49.95**
SFC-12251053F *Xerox 8" CP/M* **$49.95**
SFC-12251053M *Xerox 5¼" CP/M* **$49.95**
SFX-12251051M *NEC 5¼" CP/M* **$49.95**

Pac Man

PAC MAN - Atari

Atari's best selling game for your 800 or 400 computer.
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Circle 250 on inquiry card.

Disk Drive for Apple $319.95

Diskettes

PREMIUM DISKETTES - Jade

We proudly put our name on these high quality diskettes -

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MMD-5110103	SS, SD, 01S	$29.00
MMD-5111003	SS, SD, 10S	$29.00
MMD-5111603	SS, SD, 16S	$29.00
MMD-5120103	SS, DD, 01S	$31.00
MMD-5121003	SS, DD, 010	$31.00
MMD-5121603	SS, DD, 16S	$31.00

8" Diskettes, Box of Ten

MMD-8110103	SS, SD, 01S	$31.00
MMD-8120103	SS, DD, 01S	$39.00
MMD-8220103	DS, DD, 01S	$48.00

BARGAIN DISKETTES

MMD-5110105	5¼" SS, DD, 01S	$19.95
MMD-5220105	5¼" DS, DD, 01S	$32.95
MMD-8110105	8" SS, SD, 01S	$24.95
MMD-8120105	8" SS, DD, 01S	$32.95
MMD-8220105	8" SS, DD, 01S	$35.95

Video Monitors

HI-RES 12" GREEN - Zenith

15 MHz bandwith 700 lines/inch. P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable.

VDM-201201	List price $189.95	$129.95

12" GREEN SCREEN - NEC

20 MHz bandwidth. P31 phosphor ultra-high resolution video monitor with audio.

VDM-561200	List price $289.95	$199.95

12" COLOR MONITOR - NEC

High resolution color monitor with audio.

VDC-651212	Color monitor	$389.95
NEC-1202D	RGB color monitor	$999.95

13" COLOR MONITORS - BMC

18 MHz RGB & composite video color monitors.

VDC-421320	13" RGB Color	$329.95
VDC-421310	13" Composite video	$299.95
VDX-420090	RGB card for Apple	$149.95

COLOR MONITORS - Amdek

Reasonably priced color video monitors.

VDC-80130	13" Color I	$379.95
VDC-801320	13" Color II	$894.95
IOV-2300A	DVM board for Apple	$199.95

AMBER or GREEN MONITORS - Jade

High resolution 18 MHz compact video monitors.

VDM-751210	12" Amber phosphor	$149.95
VDM-751220	12" Green phosphor	$139.95
VDM-750910	9" Amber phosphor	$149.95
VDM-750920	9" Green phosphor	$139.95

Modems

SIGNALMAN - Anchor

Direct-connect automatic answer/originate selection, 300 Baud full duplex, Bell 103, includes RS-232 cable

IOM-5600A	Signalman	$98.50

SMARTMODEM - Hayes

Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable

IOM-5400A	Smartmodem	$224.95
IOK-1500A	Hayes Chronograph	$218.95
IOM-2010A	Micromodem II	$328.95
IOM-1100A	Micromodem 100	$368.95

EPROM Erasers

ULTRA-VIOLET EPROM ERASERS

Inexpensive erasers for industry or home.

XME-3100A	Spectronics w/o timer	$69.50
XME-3101A	Spectronics with timer	$94.50
XME-3200A	Economy model	$39.95

Single User System

THREE BOARD SET - SD Systems

4 MHz Z-80A CPU, 64K RAM (optional 256K), serial I/O port, parallel I/O port, double density disk controller, CP/M 2.2 & manual set, system monitor, control & diagnostic software. Includes SBC-200, 64K ExpandoRAM II, Versafloppy II, & CP/M 2.2 - all boards are assembled & tested.

Board set with 64K of RAM	$1095.00
Board set with 256K of RAM	$1295.00

Apple II Accessories

APPLE DISK DRIVE - Fourth Dimension

Totally Apple compatible, 143,360 bytes per drive on DOS 3.3, half-track capability - reads all Apple software, plugs right in to Apple controller as second drive, DOS 3.3, 3.2.1, Pascal, & CP/M compatible.

MSM-123200	Add-on Apple Drive	$319.95
MSM-123100	Controller for above	$89.95

16K RAM CARD - for Apple II

Expand your Apple II to 64K, use as language card, full 1 year warranty. Why spend $175.00 ?

MEX-16700A	Save over $100.00	$69.95

Z-80 CPU CARD - for Apple II

Two computers in one, Z-80 & 6502, more than doubles the power and potential of your Apple, includes Z-80 CPU card CP/M and complete manual set.

CPX-62800A	A & T with software	$249.95

APPLE-CAT - Novation

Software selectable 1200 or 300 baud, direct connect, auto-answer/auto-dial, auxiliary 3-wire RS232C serial port for printer.

IOM-5232A	Save $50.00!!!	$325.95

8" DISK CONTROLLER - Vista

New from Vista Computer, single or double sided, single or double density, compatible with DOS 3.2/3.3, Pascal, & CP/M 2.2, Shugart & Qume compatible

IOD-2700A	A & T	$499.95

2 MEGABYTES for Apple II

Complete package includes: Two 8" double-density disk drives, Vista double-density 8" disk controller, cabinet, power supply, & cables, DOS 3.2/3.3, CP/M 2.2, & Pascal compatible.

1 MegaByte Package	Kit	$1495.00
1 MegaByte Package	A & T	$1695.00
2 MegaByte Package	Kit	$1795.00
2 MegaByte Package	A & T	$1995.95

VISION 80 - Vista Computer

80 column x 24 line video card for Apple II, 128 ASCII characters, upper and lower case, 9 x 10 dot matrix with 3 dot descenders, standard data media terminal control codes, CP/M Pascal & Fortran compatible, 50/60 Hz

IOV-2400A	Vista Vision 80	$299.95

CPS MULTICARD - Mtn. Computer

Three cards in one! Real time clock/calendar, serial interface, & parallel interface - all on one card.

IOX-2300A	A & T	$179.95

HI-RES GRAPHICS CARD - Genie

Intelligent printer interface and control card allows full high resolution graphics and screen dumps.

IOP-2405A	Genie for Epson	$119.95
IOP-2410A	Genie for Okidata	$119.95
IOP-2415A	Genie for NEC/C. Itoh	$119.95

Power Strips

ISOBAR - GSC

Isolates & protects your valuable equipment from high voltage spikes & AC line noise, inductive isolated ground, 15 amp circuit breaker, U.L. listed

EME-115103	3 socket	$39.50
EME-115105	4 socket	$49.50
EME-115100	8 socket	$54.50
EME-115110	9 socket rackmount	$74.50

Single Board Computer

SUPERQUAD - Adv. Micro Digital

Single board, standard size S-100 computer system, 4 MHz Z-80A, single or double density disk controller for 5¼" or 8" drives, 64K RAM, extended addressing, up to 4K of EPROM, 2 serial & 2 parallel I/O ports, real time interrupt clock, CP/M compatible.

CPC-30800A	A & T	$724.95
IOX-4232A	Serial I/O adapter	$29.95

Z-80 STARTER KIT - SD Systems

Complete Z-80 microcomputer with RAM, ROM, I/O, keyboard, display, kludge area, manual, & workbook.

CPS-30100K	Kit with workbook	$299.95
CPS-30100A	A & T with workbook	$469.95

AIM-65 - Rockwell International

Complete 6502 microcomputer with alphanumeric display, printer, keyboard, & instruction manual.

CPK-50165A	1K AIM-65	$424.95
CPK-50465A	4K AIM-65	$474.95
SFK-74600008E	8K Basic ROM	$64.95
SFK-64600004E	4K assembler ROM	$43.95
SFK-74600020E	PL/65 ROM	$84.95
SFK-74600010E	Forth ROM	$64.95
SFK-74600030E	Instant Pascal	$99.95
PSX-030A	Power supply	$64.95
ENX-000002	Enclosure	$54.95

SPECIAL PACKAGE

4K AIM-65, 8K Basic, power supply, & enclosure

Special Package Price	$649.95

S-100 EPROM Boards

PROM-100 - SD Systems

2708, 2716, 2732 EPROM programmer with software.

MEM-99520K	Kit with software	$189.95
MEM-99520A	A & T with software	$249.95

PB-1 - SSM Microcomputer

2708, 2716 EPROM board with on-board programmer.

MEM-99510K	Kit with manual	$154.95
MEM-99510A	A & T with manual	$219.95

EPROM BOARD - Jade

16K or 32K uses 2708 or 2716 EPROMs, 1K boundary.

MEM-16230K	Kit w/o EPROMs	$79.95
MEM-16230A	A & T w/o EPROMs	$119.95

S-100 Video Boards

SPECTRUM COLOR - CompuPro

Full-function color graphics board, up to 8 colors, 256 x 192 graphics, parallel I/O port, 8K RAM.

IOV-1870A	A & T	$348.95
IOV-1870C	CSC	$398.95

MICROANGELO - Scion

Ultra-high-resolution 512 x 480, 256 color or black & white S-100 video board

IOV-1500A	A & T	$999.95

S-100 MotherBoards

ISO-BUS - Jade

Silent, simple, and on sale - a better motherboard

6 Slot (5¼" x 8⅝")

MBS-061B	Bare board	$19.95
MBS-061K	Kit	$39.95
MBS-061A	A & T	$59.95

12 Slot (9¾" x 8⅝")

MBS-121B	Bare board	$29.95
MBS-121K	Kit	$69.95
MBS-121A	A & T	$99.95

18 Slot (14½" x 8⅝")

MBS-181B	Bare board	$49.95
MBS-181K	Kit	$99.95
MBS-181A	A & T	$139.95

ACTIVE TERMINATOR - CompuPro

A true mother's helper.

TSX-100A	A & T	$59.45

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Circle 251 on inquiry card.

CompuPro Boards on Sale

S-100 CPU Boards

8086/8087 - CompuPro
16 bit, 8 or 10 MHz 8086 CPU with provisions for 8087 & 80130.

CPU-70520A	8 MHz 8086 A & T	$624.95
CPU-70520C	8 MHz 8086 CSC	$764.95
CPU-70530A	with 8087 A & T	$1224.95
CPU-70530C	with 8087 CSC	$1455.95

8085/8086 - CompuPro
Both 8 & 16 bit CPUs, standard 8 bit S-100 bus, up to 8 MHz, accesses 16 Megabytes of memory.

CPU-20510A	6 MHz A & T	$398.95
CPU-20510C	6/8 MHz CSC	$497.95

CPU-Z - CompuPro
2/4 MHz Z80A CPU, 24 bit addressing.

CPU-30500A	2/4 MHz A & T	$279.95
CPU-30500C	3/6 MHz CSC	$374.95

SBC-200 - SD Systems
4 MHz Z-80A CPU with serial & parallel I/O, 1K RAM, 8K ROM space, monitor PROM included.

CPC-30200A	A & T	$399.95

THE BIG Z - Jade
2 or 4 MHz switchable Z-80 CPU board with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600.

CPU-30201B	Bare board w/manual	$35.00
CPU-30201K	Kit with manual	$149.95
CPU-30210A	A & T with manual	$199.95

CB-2 - SSM Microcomputer
2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.

CPU-30300K	Kit with manual	$229.95
CPU-30300A	A & T with manual	$274.95

2810 Z-80 CPU - C.C.S.
2 or 4 MHz Z-80 CPU with serial I/O port & on-board monitor PROM, front panel compatible.

CPU-30400A	A & T with PROM	$289.95

2820 Z-80 DMA CPU - C.C.S.
4 MHz Z-80 CPU board with 2 serial I/O ports & Centronics parallel I/O port, separate data & status ports, DMA daisy chain compatible.

CPU-30420A	A & T with manual	$569.95

S-100 Disk Controllers

DISK 1 - CompuPro
8" or 5¼" DMA disk controller, single or double density, single or double sided, 10 MHz.

IOD-1810A	A & T	$449.95
IOD-1810C	CSC	$554.95
SFC-52506580F	8" CP/M 2.2 for Z-80	$174.95
SFC-52506586F	8" CP/M 2.2 for 8086	$299.95
SFO-54158000F	Oasis single user	$499.95
SFO-54158002F	Oasis multi-user	$849.95

VERSAFLOPPY II - SD Systems
Double density disk controller for any combination of 5¼" and 8" single or double sided, analog phase-locked loop data separator, vectored interrupts, CP/M 2.2 & Oasis compatible, control/diagnostic software PROM included.

IOD-1160A	A & T with PROM	$359.95
SFC-55009047F	CP/M 2.2 with VF II	$99.95

2242 DISK CONTROLLER - C.C.S.
5¼" or 8" double density disk controller with on-board boot loader ROM, free CP/M 2.2 & manual set.

IOD-1300A	A & T with CP/M 2.2	$399.95

DOUBLE D - Jade
High reliablity double density disk controller with on-board Z-80A, auxiliary printer port, IEEE S-100, can function in multi-user interrupt driven bus.

IOD-1200B	Bare board & hdwr man	$59.95
IOD-1200K	Kit w/hdwr & sftwr man	$299.95
IOD-1200A	A & T w/hdwr & sftwr man	$325.95
SFC-59002001F	CP/M 2.2 with Double D	$99.95

S-100 Memory Boards

256K RAMDISK - SD Systems
ExpandoRAM III expandable from 64K to 256K using 64K x 1 RAM chips, compatible with CP/M, MP/M, Oasis, Cromemco, & most other Z-80 based systems, functions as ultra-high speed disk drive when used with optional RAMDISK software.

MEM-65064A	64K A & T	$474.95
MEM-65128A	128K A & T	$574.95
MEM-65192A	192K A & T	$674.95
MEM-65256A	256K A & T	$774.95
SFC-55009000F	RAMDISK sftwr CP/M 2.2	$44.95
SFC-55009000F	RAMDISK with EXRAM III	$24.95

128K RAM 21 - CompuPro
128K x 8 bit or 64K x 16 bit static RAM board, 12 MHz, 24 bit addressing.

MEM-12810A	A & T	$1609.95
MEM-12810C	CSC	$1794.95

64K RAM 17 - CompuPro
64K CMOS static RAM board, 10 MHz, low power less than 4 watts, DMA compatible, 24 bit addressing.

MEM-64180A	64K A & T	$549.95
MEM-64180C	64K CSC	$698.95

64K RAM 16 - CompuPro
32K x 16 bit or 64K x 8 bit low power static RAM board, 10 MHz, 24 bit addressing.

MEM-32180A	RAM 16 A & T	$598.95
MEM-32180C	RAM 16 CSC	$698.95

64K STATIC RAM - SSM
IEEE 696/S-100 standard, up to 6 MHz/8 Bit, 12 MHz/16 Bit, 24 Bit extended addressing, disable-able in 2K increments

MEM-64300A	A & T	$499.95

64K STATIC RAM - Mem Merchant
64K static S-100 RAM card, 4 to 16K banks up to 8 MHz.

MEM-64400A	64K A & T	$499.95

2065 64K RAM - C.C.S.
4 MHz bank port/bank byte selectable, extended addressing, 16K bank selectable, front panel compatible.

MEM-64565A	64K A & T	$349.95

2066 64K RAM - C.C.S.
64K RAM board with bank and block select switching functions for Cromemeco Cromix & Alpha Micro.

MEM-64566A	64K A & T	$424.95

64K EXPANDORAM II - SD Systems
Expandable RAM board from 16K to 64K using 4116 RAM chips.

MEM-16630A	16K A & T	$344.95
MEM-32631A	32K A & T	$364.95
MEM-48632A	48K A & T	$384.95
MEM-64633A	64K A & T	$399.95

MEMORY BANK - Jade
4 MHz S-100 bank selectable expandable to 64K.

MEM-99730B	Bare board w/manual	$49.95
MEM-99730K	Kit with no RAM	$179.95
MEM-32731K	32K kit	$199.95
MEM-64733K	64K kit	$249.95
Assembled & Tested		add $50.00

32K RAM 20 - CompuPro
32K static RAM, up to 10 MHz, disable-able in 4K banks, bank select or 24 bit addressing.

MEM-16180A	16K A & T	$259.95
MEM-16180C	16K CSC	$324.95
MEM-24180A	24K A & T	$324.95
MEM-24180C	24K CSC	$384.95
MEM-32185A	32K A & T	$384.95
MEM-32185C	32K CSC	$449.95

16K STATIC RAM - Mem Merchant
4MHz lo-power static RAM board, IEEE S-100, bank selectable, addressable in 4K blocks, disable-able in 1K segments extended addressing.

MEM-16171A	16K A & T	$149.95

S-100 I/O Boards

SYSTEM SUPPORT 1 - CompuPro
Real time clock, three 16 bit interval timers, dual interrupt controllers(15 levels), up to 4K EPROM/RAM, RS-232C serial channel, provision for 9511A/9512 math chip.

IOX-1850A	SS1 A & T	$359.95
IOX-1850C	SS1 CSC	$459.95
IOX-1855A	with 9511 A & T	$554.95
IOX-1855C	with 9511 CSC	$654.95
IOX-1860A	with 9512 A & T	$554.95
IOX-1860C	with 9512 CSC	$654.95

INTERFACER 1 - CompuPro
2 serial I/O ports 50-19.2K baud.

IOI-1810A	A & T	$218.95
IOI-1810C	CSC	$288.95

INTERFACER 2 - CompuPro
3 parallel, 1 serial, & interrupt timer.

IOI-1820A	A & T	$218.95
IOI-1820C	CSC	$288.95

INTERFACER 3 - CompuPro
5 or 8 channel serial I/O board for interrupt driven multi-user systems up to 250K baud.

IOI-1835A	5 port A & T	$558.95
IOI-1835C	5 port CSC	$628.95
IOI-1838A	8 port A & T	$628.95
IOI-1838C	8 port CSC	$749.95

INTERFACER 4 - CompuPro
3 serial, 1 parallel, 1 Centronics parallel.

IOI-1840A	A & T	$314.95
IOI-1840C	CSC	$414.95

MPX - CompuPro
Multi-user I/O multiplexer & interrupt controller with on-board 8085A-2 CPU & 4K or 16K of RAM.

IOI-1875A	4K MPX A & T	$444.95
IOI-1875C	4K MPX CSC	$534.95
IOI-1880A	16K MPX A & T	$584.95
IOI-1880C	16K MPX CSC	$674.95

I/O-8 - SSM Microcomputer
Eight software programmable serial I/O ports, 110 -19.2K Baud, ideal for multi-user systems

IOI-1018A	A & T	$469.95

I/O-5 - SSM Microcomputer
Two serial & 3 parallel I/O ports, 110-19.2K Baud

IOI-1015A	A & T	$289.95

MPC-4 - SD Systems
Intelligent 4-port serial I/O card, on-board Z-80A, 2K RAM, 4K PROM area, on-board firmware, fully buffered, vectored interrupts, four CTC channels, add to SD Board set for powerful multi-user system

IOI-1504A	A & T w/software	$495.00

I/O-4 - SSM Microcomputer
2 serial I/O ports plus 2 parallel I/O ports.

IOI-1010B	Bare board w/manual	$35.00
IOI-1010K	Kit with manual	$179.95
IOI-1010A	A & T with manual	$249.95

2830 6 PORT SERIAL - C.C.S.
Six asynchronous RS-232C serial I/O ports with programmable baud rates.

IOI-1040A	A & T with manual	$529.95

2710 4 PORT SERIAL - C.C.S.
Four RS-232C serial I/O ports with full handshaking.

IOI-1060A	A & T with manual	$319.95

2719 2 SER & 2 PAR - C.C.S.
Two RS-232C serial I/O ports plus two 8 bit parallel I/O ports.

IOI-1080A	A & T with manual	$349.95

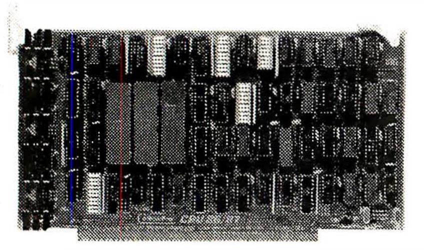
Prices may be slightly higher at our retail locations. Please call the store nearest you for local price and availability.

Circle 251 on inquiry card.

THERE ARE NO BETTER BOARDS — THERE ARE NO BETTER PRICES!

CompuPro SYSTEMS FROM

PRIORITY ONE ELECTRONICS



CPU BOARDS

CO-PROCESSOR 8086/8087

16 bit 8 or 10 MHz 8086 CPU with sockets for 8087 and 80130

Part No.	Description	List Price	Our Price
BIGBT186A	A&T 8MHz 8086 only	$695.00	$ 495.00
BIGBT186C	CSC 10MHz 8086 only	$850.00	$765.00
BIGBT186A87	A&T with 8087 option	$995.00	$795.00
BIGBT186C87	CSC with 8087 option*	$1150.00	$1065.00

*8087 Limits clock speed to 5MHz

SAVE $200.00!!

DUAL PROCESSOR 8085-8088

6 or 8 MHz Provides true 16 Bit Power with a standard 8 bit S-100 bus

BIGBT1612A	A&T 6Mhz	$425.00	$325.00
BIGBT1612C	CSC 6/8 MHz	$525.00	$425.00

SAVE $100.00!!

TURN PAGE FOR COMPLETE COMPUPRO SYSTEMS

CPUZ - Z80B CPU NOW 6MHz!

3/6 MHz Z80B CPU with 24 Bit Addressing. FASTEST Z80 CPU AVAILABLE!

BIGBT160A	3/6 MHz A&T	$295.00	$225.00
BIGBT160C	3/6 MHz CSC	$395.00	$375.00



DISK CONTROLLERS

DISK 1 FLOPPY CONTROLLER

Fast DMA, Soft Sector, Controls 8" or 5¼" Single or Double Density. OUR BEST!

BIPDB171ACPM	A&T w/CP/M2.2 & BIOS	$670.00	$450.00
BIGBT171C	CSC	$595.00	$555.00
BIGBTCPM80*	CP/M 2.2 for Z80/8085 with manuals & BIOS 8" S/D d isk		$175.00
BIGBTCPM86	CP/M for 8086 with manuals & BIOS 8" S/D disk		$300.00

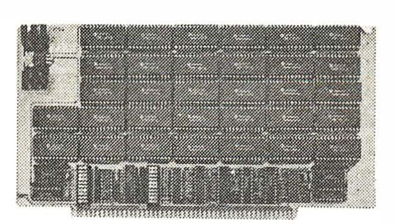
SAVE $220.00!!

DISK 2/SELECTOR CHANNEL HARD DISK CONTROLLER

Fast DMA 2 board set. Controls 4 Shugart 4000 series or Fujitsu 2300 type drives. Includes CP/M 2.2®

BIGBT177A	Assembled & Tested	$795.00	$595.00
BIGBT177C	CSC	$895.00	$850.00

SAVE $200.00!!



CMOS RAM SALE!

RAM 17 - 64K CMOS STATIC RAM

RAM 17, 12 MHz, 2 Watt, DMA Compatible 24 Bit Addressing

Part No.	Description	List Price	Our Price
BIGBT175A64	64K A&T	$599.00	$369.00
BIGBT175C64	64K CSC	$750.00	$699.00

SAVE $236.00!!

RAM 16 - 32K x 16 BIT CMOS STATIC RAM

8 and/or 16 Bit
816 RAM 16 12 MHz, 32K x 16 or 64K x 8 IEEE/696 16 Bit 2 Watt, 24 Bit Addressing

BIGBT180A	64K A&T	$650.00	$429.00
BIGBT180C	64K CSC	$750.00	$899.00

SAVE $221.00!

NEW! RAM 21 - 128K STATIC RAM

816 RAM 21 12MHz, 128K x 8 or 64K x 16 IEEE/696 8 or 16 Bit 1.2 Amps, 24 Bit Addressing

BIGBT190A	128K A&T	$1695.00	$ 995.00
BIGBT190C	128K CSC	$1895.00	$1795.00

SAVE $700.00!!!

M-DRIVE SOLID STATE DISK DRIVE, 3500% FASTER!

Not Really, But the Next Best Thing for CompuPro 8085/88 Users. Call for Detail on M-Drive.

M-Drive requires a 6MHz CPU 8085/88 dual processor, Disk 1 DMA disk controller and System Suport 1 Multifunction Board

BIGBTM0128KA	128K of A&T memory & M-DriveSoftware	$1198.00
BIGBTM0128KC	128K of CSC memory & M-Drive Software	$1398.00
BIGBTM0256KA	256K of A&T memory & M-DriveSoftware	$2395.00
BIGBTM0258KC	256K of CSC memory & M-Drive Software	$2795.00

STATIC MEMORY BOARDS

RAM 20 - 32K STATIC RAM

RAM 20 10 MHz, 4K byte block disable, bank select or 24 bit addressing available 8, 16, 24 or 32K

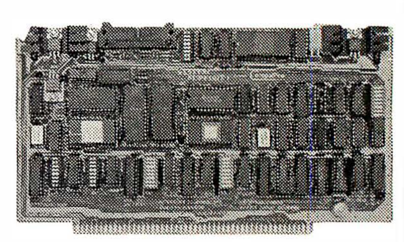
BIGBT164AA8	8K A&T	$210.00	$190.00
BIGBT164AC8	8K CSC	$280.00	$260.00
BIGBT184AA16	16K A&T	$285.00	$260.00
BIGBT164AC16	16K CSC	$355.00	$325.00
BIGBT164AA24	24K A&T	$355.00	$325.00
BIGBT164AC24	24K CSC	$425.00	$385.00
BIGBT164AA32	32K A&T	$425.00	$295.00
BIGBT164AC32	32K CSC	$495.00	$450.00



S-100 MAINFRAME

110V 60Hz CVT Mainframe uses famous 20 slot COMPUPRO Motherboard. (55 lbs.)

BIGBTENC20RM	20 Slot Rackmount	$895.00	$760.00
BIGBTENC20DK	20 Slot Desk Top	$825.00	$699.00



I/O BOARDS

SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

Serial port (software prog. baud), 4K EPROM or RAM provision, 15 levels of interrupt, real time clock, optional math processor

Part No.	Description	List Price	Our Price
BIGBT182A	Assembled & Tested	$399.00	$295.00
BIGBT162C	CSC	$495.00	$460.00
BIGBT8231	Math Chip		$195.00
BIGBT8232	Math Chip		$195.00
BIGBT162AM1	A&T with 8231 Math Chip		$490.00
BIGBT162CM1	CSC w/8231 Math Chip		$655.00
BIGBT162AM2	A&T w/8232 Math Chip		$490.00
BIGBT162CM2	CSC w/8232 Math Chip		$655.00

SAVE $100.00!!

MPX CHANNEL BOARD

I/O Multiplexer, using 8085A-2 CPU on board with 4K RAM

BIGBT166A4	Assembled & Tested	$495.00	$395.00
BIGBT166C4	CSC	$595.00	$475.00
	With 16K RAM		
BIGBT166A16	Assembled & Tested	$649.00	$525.00
BIGBT166C16	CSC	$749.00	$649.00

INTERFACER 1

Two Serial I/O

BIGBT133A	Assembled & Tested	$249.00	$199.95
BIGBT133C	CSC	$324.00	$298.00

INTERFACER 2

Three parallel, one serial I/O board

BIGBT150A	Assembled & Tested	$249.00	$199.95
BIGBT150C	CSC	$324.00	$289.00

INTERFACER 3

Eight channel multi-use serial I/O board

BIGBT1748A	Assembled & Tested	$699.00	$469.00
BIGBT1748C	CSC 200 hr. 8 Port	$849.00	$750.00
BIGBT1745A	Assembled & Tested	$599.00	$399.00
BIGBT1745C	CSC 200hr. 5 port	$699.00	$829.00

INTERFACER 4

Three Serial, 1 Parallel, 1 Centronics Parallel

BIGBT187A	Assembled & Tested	$350.00	$315.00
BIGBT187C	CSC	$450.00	$415.00

SPECTRUM COLOR GRAPHICS

Color Graphics board with Parallel I/O

BIGBT144A	Assembled & Tested	$399.00	$249.00
BIGBT144C	CSC	$449.00	$339.00
BIGBT20	Sublogic Universal Graphics Interpreter Soft ware		$35.00

SAVE $150.00!

S-100 MOTHERBOARDS

Active termination, 6-12-20 Slot

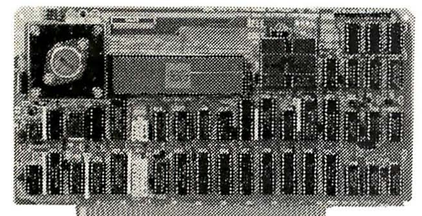
BIGBT153A	A&T 6 slot, 2 lbs.	$140.00	$125.00
BIGBT153C	CSC 6 slot, 2 lbs.	$190.00	$175.00
BIGBT154A	A&T 12 slot, 3 lbs.	$175.00	$155.00
BIGBT154C	CSC 12 slot, 3 lbs.	$240.00	$220.00
BIGBT155A	A&T 20 slot, 4 lbs.	$265.00	$235.00
BIGBT155C	CSC 20 slot, 4 lbs.	$340.00	$310.00

SAVE!

Circle 378 on inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604





CPU BOARDS

CPU/68000 - 8MHz 68000 CPU

16 bit 68000 CPU with on board ROM containing MACSBUG Monitor or Motorola 68541 Memory Management Unit (MMU).

Part No.	Description	List Price	Our Price
BIDULCPU68000	A&T with Monitor	$1195.00	$1075.00
BIDULCPU68000M	A&T with MMU	$1495.00	$1395.00

MEMORY BOARDS

DMEM256KP-256K DYNAMIC MEMORY MODULE

256Kb with byte parity error detection for 8 or 16 bit computers

BIDULDMEM256	256K A&T	$1495.00	$1395.00

CMEM NONVOLATILE CMOS MEMORY

Nonvolatile CMOS memory with 3-10 year battery backup on board.

BIDULCMEM8	8K A&T	$695.00	$629.00
BIDULCMEM16	16K A&T	$795.00	$725.00
BIDULCMEM32	32K A&T	$995.00	$940.00

2716/2732 EPROM BOARD WITH 16 BIT DATA PATHS

Designed to hold 32Kb of 2716 type or 64Kb of 2732 type EPROMs, or ROMs for read only use with 16 bit CPU systems.

BIDULEPROM32	2716 EPROM Board A&T	$295.00	$280.00
BIDULEPROM64	2732 EPROM Board A&T	$295.00	$280.00

REAL TIME & DATA AQUISITION

SIO4/DMA INTELLIGENT CONTROLLER

4 port RS232 interface with DMA transfers for output. 256b FIFO input buffer; On board 8085A-2 processor; 16 program selectable baud rates and occupies only 16 I/O addresses. Ideal for DUAL UNIX® or other multi-user systems.

NEW!

BIDULSIO4DMA	Assembled & Tested	$695.00	$650.00

AIM 12-12 BIT A/D CONVERTER

A/D input module with 12 bit accuracy, 32 input channels and optional instrumentation amplifier

BIDULAIM12	A&T with Instrumentation Amp.	$745.00
BIDULAIM12B	A&T without Instrumentation Amp.	$660.00

AOM 12-12 BIT D/A CONVERTER

D/A output module, 4 channels, 12 bit accuracy. Optional VIC420 industrial output module (4-20Ma), 4 channels, used in conjunction with AOM 12.

BIDULAOM12	Assembled & Tested	$675.00	$640.00
BIDULVIC420	Assembled & Tested	$675.00	$640.00

CLK24-NONVOLATILE CLOCK/CALENDAR

Day, date, hours, minutes, seconds, and 3-5 year battery backup on board. Read or write directly from I/O port. Jumperable for 64Hz UNIX® or real time applications.

BIDULCLK24C	A&T w/64Hz Interrupt	$300.00	$285.00

SALE SOFTWARE

DIGITAL RESEARCH

BIDIRCPM	CP/M* 2.2 Control Program/ Microcomputers	$150.00
BIDIRMAC	MAC* Macro Assembler	$ 90.00
BIDIRRMAC	RMAC* Relocating MAC	$200.00
BIDIRSID	SID* Symbolic Instruction Debugger	$100.00
BIDIRTEX	TEX* Text Formatter	$100.00
BIDIRDES	DESPOOL* Background Print Utility	$ 50.00
BIDIRCB80	CBASIC* Programming Language	$150.00
BIDIRCB86	CBASIC-86* Programming Language	$325.00

*Trademark of Digital Research

MICROPRO INTERNATIONAL

BIMOSWDSTR	Wordstar Version* 3.0	$249.00
BIMOSMLMRG	Mail Merge*	$100.00
BIMOSSPSTR	Spell Star*	$150.00
BIMOSCALSTR	Calc Star*	$200.00
BIMOSDATSTR	Data Star*	$200.00
BIMOSSUPSET	Supersort*	$150.00

*Trademark of Micropro International

SORCIM

BISORSCAL	SUPERCALC* a Superior Electronic Worksheet	$229.00
BISORACTI	ACT I* 8080/Z80 Assembler	$175.00
BISORACTII	ACT II* 8086/8088 Assembler	$175.00
BISORTRNS	TRANS* 8086/8088 Translator	$125.00
BISORPM80	PASCAL/M* REL4 8080/8085/Z-80	$395.00
BISORPM86	PASCAL/M* 8086	$495.00

*Trademark of Sorcim

MICROSOFT

BIMOSBAS80	BASIC-80* Version 5.X Extended Disk Basic	$300.00
BIMCPBASC	BASIC* Compiler Version 5.X	$395.00
BIMOSMFT	FORTRAN-80*	$500.00

*Trademark of MicrosoftConsumer Products





110V 60Hz CVT Mainframes, the best money can buy!
12 Slot ±8V 17±16V @2A
22 Slot±8V @ 30A± 16V @ 4A

PART NO.	DESCRIPTION	LIST PRICE	SALE
BITEIMCS112	12 Slot Desk	$755.00	$620.00
BITEIMCS122	22 Slot Desk	$910.00	$745.00
BITEIRM12	12 Slot Rackmount	$800.00	$655.00
BITEIRM22	22 Slot Rackmount	$965.00	$790.00

Shipping Weight: On 12 Slot Mainframes: 45 lbs. On 22 Slot Mainframes: 55 lbs.

S-100 MAINFRAME WITH 12 SLOT MOTHERBOARD AND CUTOUTS FOR 3 - 5¼" FLOPPY DISK DRIVES

+8V @ 17A ±16V @ 2A +12V @ 1.2A Internal Power Cable

BITEITF12	12 Slot desk	$745.00	$605.00
BITEIRF12	12 Slot Rackmount	$855.00	$695.00

Shipping Weight: On 12 Slot Desk: 40 lbs. On 12 Slot Rackmount: 45 lbs.

DUAL 8" DISK DRIVE CHASSIS

For two Shugart 801R or two Qume DT-8 size drives with internal power cables provided +24V @ 1.5A +5V @ 1.0A - 5V @ .25A

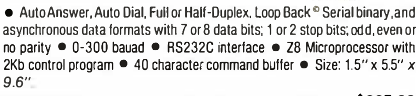
BITEIDFDD	Desk Top	$565.00	$480.00
BITEIRFDD	Rackmount	$725.00	$650.00

Shipping Weight: On Desk Top: 40 lbs. On Rackmount: 45 lbs.

PRIORITY ONE ELECTRONICS is a master distributor for TEI. Dealers & OEM's call for quantity pricing.

Hayes





● Auto Answer, Auto Dial, Full or Half-Duplex, Loop Back© Serial binary, and asynchronous data formats with 7 or 8 data bits; 1 or 2 stop bits; odd, even or no parity ● 0-300 bauad ● RS232C interface ● Z8 Microprocessor with 2Kb control program ● 40 character command buffer ● Size: 1.5" x 5.5" x 9.6"

BIDCH0200P	Smartmodem (Sh. Wt. 6 lbs.)	$279.00	$225.00
BIDCH0400P	Smartmodem 1200 baud (6 lbs.)	$699.00	$649.00
BIDCH0300P	Chronograph (Sh. Wt. 3 lbs.)	$249.00	$205.00
BIDCH0100P	Micromodem 100 (Sh. Wt. 4 lbs.)	$399.00	$325.00
BIDCH2901D	CP/M® 8" Terminal Program for above		$ 25.00
BIDCH0000P	Micromodem II	$379.00	$299.00
BIDCH24010	Datacom (PASCAL patch) for above		$ 50.00

TeleVideo

WORLD'S BEST SELLING TERMINAL!

Extra Memory Pages FREE!!

BIPOBTLV9252P*	$749.00

*TeleVideo 925 w/free 2nd page memory kit, a $95.00 value!

BIPOBTLV9504P*	$949.00

*TeleVideo 950 w/free 2nd, 3rd & 4th page memory kit, $285.00 value

BITLV910	$609.00

With emulations & foreign languages

BITLV910BLK	$609.00

Black mode version of above

(Shipping Weight 37 lbs.)



BEST BUYS!

SEND $1.00 TODAY FOR THE NEW, FULL COLOR SPRING 1982 ENGINEERING SELECTION GUIDE!

MORROW DESIGNS

ONE

SALE! SALE!

S-100 5-26 MB HARD DISK SUBSYSTEMS

5 - 16 Mb DMA SUBSYSTEMS

Each subsystem includes DMA Hard Disk Controller, Seagate ST506 5 Mb ST412 10 Mb, or CMI 16Mb 5¼" Hard Disk, Cabinet, power supply, CP/M™2.2 and Microsoft BASIC.

BIMDSDMAM*	Software supplied on 8" IBM 3740 disk with blank I/O and INSTALL program
BIMDSDMAM*2B	Software configured for Morrow DJ/2B controller and Mult I/O as console
BIMDSDMAM*DMA	Software configured for Morrow DJ/DMA controller and Mult I/O as console
BIMDSDMAM*NS	Software suplied on 5¼" 10 sector North Star disk with blank I/O and INSTALL Program

Replace * in above part numbers with **5** for 5Mb Subsystems **10** for 10Mb Subsystems, or **16** for 16Mb Subsystems

DISCUSM5	- 5Mb Subsystems	$2195.00	$1495.00
DISCUSM10	- 10Mb Subsystems	$2795.00	$2375.00
DISCUSM16	- 16Mb Subsystems	$3495.00	$2975.00

(order by part numbers listed above)

DISCUS HDC 20-26 Mb SUBSYSTEMS

Each subsystem includes HDCA3 I/O mapped controller, Shugart SA4008 14" 26Mb or Fujitsu 2308 8" 20Mb Hard Disk, cabinet, power supply, CP/M™2.2 & Microsoft BASIC. (Shipping Weights: M20 40 lbs., M26 3 boxes 6, 29, & 45 lbs.)

BIMDSHDC20	Discus M20 A&T	$4495.00	$3394.00
BIMDSHDC26	Discus M26 A&T	$4495.00	$3394.00

SSM

VIDEO AND I/O

VB 3 - HIGH RESOLUTION VIDEO

80 x 25 or 50 character video display Memory Mapped, Parallel Keyboard port

BISSMVB3A24	80 x 24 A&T	$499.00	$419.00
BISSMVB3UP	80 x 50 Line Upgrade		$ 39.00

I/O 4

Two serial I/O, two parallel I/O

BISSMI04B	Assembled & Tested	$290.00	$260.00

NEW! **I/O 5**

2 Serial, 3 parallel Including 1 Centronics

BISSMI051	Assembled & Tested	$329.00	$289.00

NEW! **I/O 8**

8 Port Serial I/O with Timer

BISSMI08A	Assembled & Tested	$550.00	$469.00

CPU, RAM & PROM

CB2 Z80 CPU

2/4 MHz will accept 2716, or 2732, or RAM

BISSMCB2A	Assembled & Tested	$299.00	$269.00
BISSMZ80M	SSM Z80 Monitor		$ 89.00

MB10A 16/8K 8/16 BIT STATIC RAM

16K byte/8K word, 24 bit extended, addressing, "M write," Phantom disable, addressable in 4K blocks

BISSMMB10A	Assembled & Tested	$299.00	$275.00

MB8A 1K/16K EPROM BOARD

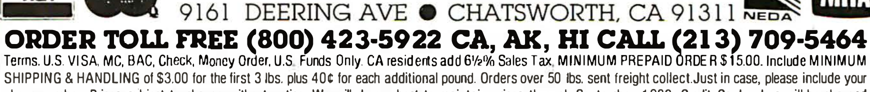
1K/16K 2708 EPROM board, disable in 1K increments

BISSMMB8AA	Assembled & Tested	$179.00	$159.00

PBI PROM PROGRAMMER

Programs 2708 or 2716's, operates as a 4K/8K EPROM BOARD AS WELL

BISSMPB1A	Assembled & Tested	$265.00	$219.00





NEDA

ORDER TOLL FREE (800) 423-5922 CA, AK, HI CALL (213) 709-5464

Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax, MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through September, 1982. Credit Card orders will be charged appropriate freight. If you haven't received your Spring '82 Engineering Selection Guide, send $1.00 for your copy today!. Sale prices are for prepaid orders only.

Circle 378 on inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604

COMPLETE CompuPro SYSTEMS

FREE SUPERCALC-86! FREE dBASE II!! AND A TELEVIDEO TERMINAL FOR ONLY $1.00!!

WHY SETTLE FOR LESS?!





PERFORMANCE, QUALITY, RELIABILITY

HIGH PERFORMANCE SYSTEMS DESIGNED TO EXPAND WITH YOUR NEEDS

All CompuPro systems have been designed with your future in mind. Each system is expandable so you can upgrade your system as your needs continue to grow. Hard disk storage is also available with the new DISK 2 DMA Winchester disk controller. Unlike many "personal" computers, your CompuPro system will not become obsolete when it is time to expand. The modular design of the IEEE 696/S-100 bus allows you to plug in additional boards when they are needed. CompuPro system components feature the latest state-of-the-art technology to prevent obsolescence.

Each CompuPro system component is fully assembled and tested under rigorous burn-in conditions at the factory and then shipped to Priority 1 Electronics, your authorized CompuPro Systems Center, for final integration and configuration. CompuPro systems carry the best warranty in the business: on full year. The Qume drives have a full six month warranty, the best drive warranty anywhere. The components are integrated into a complete system by a factory trained Priority 1 Electronics technician. The systems are then partially disassembled for shipping. After a short time for unpacking and check-out, your CompuPro system will be ready to load and go!

SYSTEM BASICS

All systems include a CPU 8085/88 Dual Processor or CPU (8085 runs at 6MHz, the 8088 runs at 8MHz); Disk 1 lightning fast DMA floppy disk controller; CP/M® 2.2 and CP/M 86™ operating systems; Sorcim's SuperCalc-86™ electronic spread sheet program; two double-sided, double-density Qume DT-8 disk drives in an attractive desk top enclosure; rugged Desk Enclosure 2 with 20 slot actively terminated motherboard, fan, air and line filters, and constant voltage power supply for years of reliable operation; internal I/O cables and floppy disk data cable; complete documentation for each system component with a system integration guide. In addition to the above hardware and software, each configuration adds a unique combination of RAM, I/O, and other special purpose boards.

System 816/A — Entry Level Single-User System

System 816/A is an excellent choice for an entry level, single user system that's designed with future expansion in mind. 816/A includes Interfacer 4 (three serial I/O ports, parallel port, and Centronics/Epson-style port), two RAM 17s for 128K of fast, static memory, and System Support 1 (clock/calendar, RAM/ROM/match processor options, RS-232C serial port, interrupt controllers, interval timers, and more), and Ashton-Tate's dBase Junior™, an upgradeable subset of their popular dBase II data base management software. This combination of components means superb computing today with an option for future expansion — all the way up to a multi-user system. System 816/A is priced at $5495.00, a savings of over $1000.00 compared to all components purchase separately.

BIGBTSYS816ADA	*Single User System Desk Top, Assembled & Tested*	**$5495.00**
BITLV910* or **BITLV910BLK***	*TeleVideo 910 or 910 BLK with purchase of above system*	**$1.00**

System 816/B — M-Drive Single user System

System 816/B is an ultra-high performance single user system which includes Interfacer 3-5 (five serial ports), 256K of fast, static RAM, System Support 1, and Ashton-Tate's complete dBase II™ data base management software. Plus, System 816/B's implementation of CP/M® includes M-Drive software, which turns the system RAM into a pseudo-disk drive for exceptionally fast computing. This system sells for only $6995.00, a savings of over $1800.00 compared to all components purchased separately.

BIGBTSYS816BDA	*M-Drive System Desk Top, Assembled & Tested*	**$6995.00**
BIPDBTLV9252P*	*TeleVideo 925 w/2nd page of memory- with purchase of above system*	**$1.00**

System 816/C — Entry Level Multi-User System

System 816/C is the only high performance multi-user system which allows both 8 and 16 bit programs to run simultaneously; it also makes for an unparalleled single user system. It includes Interfacer 3-8 (eight serial ports), 384K of fast, static RAM, System Suport 1, dBase II™, SuperCalc-86™, M-Drive software, and CompuPro's MP/M 816™ multi-user operating system that allows you to run both 8 and 16 bit software *simultaneously*. System 816/C suports up to three users simply by adding appropriate terminals: for more users, just add more CompuPro RAM and terminals. The system is priced at $8995.00, a savings of over $2300.00 compared to all components purchased separately.

BIGBTSYS816CDA	*Multi-User System Desk Top, Assembled & Tested*	**$8995.00**
BIPDBTLV9252P*	*TeleVideo 925 with 2nd page of memory- with purchase of above system*	**$1.00**

Limit 1 terminal at $1.00 per system. Purchase of 8' RS232 Cable, Part Number **CNDRS2328F at $19.95, is required for system/terminal integration.*

Rack mount and CSC systems are also available; please call or write for details. All CompuPro systems are shipped via motor or air freight collect; please specify at time of order. All boards are shipped in standard configurations.

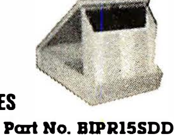
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5" DISKETTES

SOFT SECTOR

40 TRACK SINGLE SIDED DOUBLE DENSITY WITH HUB REINFORCING RINGS

PKG. OF 10/$19.95



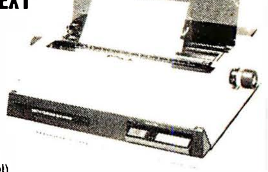
BONUS!

FREE!! KASSETTE 10 LIBRARY CASE WITH PACKAGE OF 10 DISKETTES a $4.25 VALUE — Part No. BIPR15SDD

BIPR150	package of 80 less Library Case	**$120.00**
BIPR18SD	package of 10 8" S.S/D.D. Diskettes no sleeves	**$20.00**
5 or more packages		**$18.00**

SMITH-CORONA TP-1

LETTER QUALITY - ELECTRONIC TEXT PRINTER



$649.00

BISCMTP1S10 (Serial)
BISCMTP1P10 (Parallel)

• 12 CPS • 10 CPI • 6LPI • SERIAL OR PARALLEL INTERFACE • 50-19.2K Baud • Friction Feed • 88 Character

BISCMI2825	TP1	Black Milar Ribbon	**$3.50**
BISCM12858	TP1	Black Fabric Ribbon	**$7.50**

SANYO

FCC CLASS 2 APPROVED DATA DISPLAY MONITORS



SPECIFICATIONS:

Viewing Screen	12" diagonal; 75 square inches DM2112: P31 phosphor
Scanning System	525 lines; 60 fields/second; overscan
Horizontal Resolution	600 lines, center
Signal Input	1.0 volt p-p composite video; 75 ohms

BISYODM2112

List Price: $160.00 **$SALE: $119.00**

OTHER SANYO MONITORS ON SALE TOO!!

Part No.	Description	List Price	SALE
BISYOVM4509	9"B&W P4, 10MHz (15 lbs.)	$190.00	**$149.00**
BISYODM5109CX	9"Green, P31, 10MHz (15 lbs.)	$200.00	**$159.00**
BISYODM8012CX	12"B&W P4, 18MHz (24 lbs.)	$250.00	**$195.00**
BISYODM8112CX	12"GReen, P31, 18MHz (24 lbs)	$260.00	**$199.00**
BISYOVMC6013	13"Color, 16 x 64 (35 lbs.)	$470.00	**$375.00**
BISYODM8113*	13"RGB Color (35 lbs.)	$895.00	**$795.00**

**As used with IBM P.C.*

APPLE DISK DRIVES



Give your APPLE II® a Fourth Dimension — the totally compatible 5¼" drive that takes your system farther, faster. With read/write electronics so advanced that reading errors are virtually eliminated. With a track zero microswitch that keeps boot and track access smooth and quiet. With the ability to read half-track software and up to 143,360 bytes on DOS 3.3®. With similar performance on DOS 3.2.1®, Pascal® or CP/M® operating systems. And, the disk enclosure mates perfectly with APPLE cabinetry.

EXTENDED WARRANTY

Fourth Dimension offers a 12 month parts and labor warranty at no cost to you! (Gee, this really looks good!)

BIFDS40A List Price: $419.00 **SALE: $369.00**

2 or More, only $350.00 each

BIFDS40AC* APPLE II® Disk Drive Controller **$115.00**

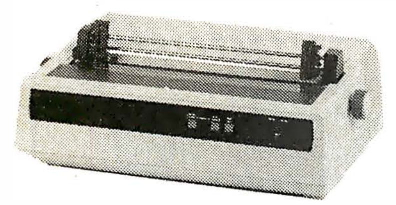
**Sold only with purchase of Fourth Dimension Drive*

SEE IMPORTANT NOTICE ON PAGE 604

Circle 379 on inquiry card.



LETTER QUALITY PRINTERS



80 CHARACTERS PER SECOND

The Fujitsu SP83 letter quality printer from Sellum is not only the fastest daisy wheel letter quality printer on the market, it is also the most versatile. Its four interfaces and five personality protocols make it compatible with just about any computer and word processing package on the market today. The printer is built to be solid and quiet; it won't shake the office down with every carriage return. It also has a 16K buffer (48K optional). The buffer allows your computer to send data out to the printer and not have to wait for it before allowing you to continue. No more staring at the screen waiting for the printer to finish!

Interfaces: • RS232C and Current Loop • Centronics type parallel • IEEE/488 • All are DIP switch selectable.

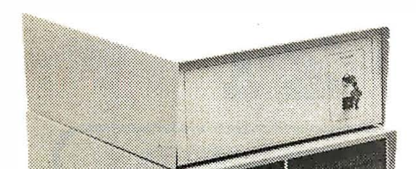
Personality Protocols: • NEC5510 • DIABLO 630 • QUME Sprint 9 • IBM Personal Computer • ATARI (Centronics 737).

More Special Features: • Z80 CPU • 50-19.2K baud on serial interface • Distinct alarm sound for each error condition • Intelligent bi-directional logic seeking • Complete word processing features including sub and super script, underlining, and double-strike characters • Auto reprint • Auto Clear • Proportional spacings and supports automatic justification • Front panel forms control • 12K ROM • Complete Vector plotting routines • Compatible with most mechanical sheet feeders • Quiet - 60db • Six month warrantee

Part No.	Description	List Price	Our Price
BISLMF86	Printer w/16K Buffer	$3495.00	$2795.00
BISLMF86B48	Printer w/48K buffer	$3895.00	$3095.00
BISLMF88VFT	Optional vertical forms tractor		$200.00
BISLMSD25000	RS-232 Cable		$60.00
BISLMPA36001	Centronics Parallel Cable		$60.00

Call for pricing on sheet feed options & cables not listed
(Printer shipped via motor freight collect)

Para Dynamics



18 SLOT S-100 MAINFRAME

CVT Power Supply, forced air cooling; security lock 120 or 220V AC at 50 or 60Hz+8V@20A, ±16@3.5

BIPDN2018D	Desk Top	$799.00	$899.00
BIPDN2018R	Rack Mount	$849.00	$749.00

8 SLOT S-100 MAINFRAME WITH CUTOUTS FOR 2 5¼" DISK DRIVES

+5@5A, -5@500MA, +8@ 15A, +12@6A, +16@2, -16@2

BIPDN25080	Desk Top	$899.00	$789.00
BIPDN2508R	Rack Mount	$949.00	$839.00

DISK DRIVE FACILITY

Accommodates two 8" floppy drives, of Shugart, Qume, or similar design and dimensions. 110 or 220V AC at 50 or 60Hz CVT power.

BIPDN22000	Desk Top	$659.00	$579.00
BIPDN2200R	Rack Mount	$679.00	$595.00



PRONTO

Free standing cabinet. Will accept 2, 8" Floppy disks and 1, 8" Rigid disk. 18 slot card cage will accept the double height 10" x 10" S-100 cards (Alpha Micro and others) CVT Power Supply.

+24@7A, +16@2.2A, -16@3.5A, +8@20A, +5@5A

BIPDN2818	PRONTO	$1295.00	$1129.00

PRONTO COMPLETE WITH POWER SUPPLY POWER-UP SEQUENCER

BIPDN2818S	with sequencer	$1395.00	$1249.00

Shipped motor freight collect

FREE TRACTOR AND FREE OKIGRAPH!!

OKIDATA



COMPARE OKIDATA'S FEATURES TO ANY OTHER PRINTER! COMPARE PRIORITY ONE'S PRICES TO ANY — THEN DECIDE!

Don't be fooled by those who try to "soak" you for the options

- *BI-DIRECTIONAL-120 CPS*
- 80 CPL @ 10CPI for 82A
- *9 x9 Matrix (Alphanumeric)*
- *132CPL @ 10CPI for 83A&84*
- *6x9or12 Matrix for graphics*
- *82A & 83A have both Centronics Parallel & 1200 baud Serial I/O*
- *10 different character sets Per Inch*
- *Self Test*

All three printers feature 10 front panel switch selectable for lengths; 10 lengths from 3" to 14". Front or bottom paper loading of up to 4 part forms and tear bar. All of these features make OKIDATA the best value in low cost printers!

Part No.	Description	List Price	SALE
BIPDBOKI82ATG	Okidata 82A w/tractor and graphics		$539.00
BIPDBOKI83ATG	Okidata 83A w/tractor & graphics		$750.00
BIOKISER2KBF	9600 Baud 2K serial buffer/interface		$150.00
	with simultaneous purchase of printer		$ 99.00
BIOKIDAT84AP	132 column printer parallel interface with graphics and tractor		$1019.00
BIOKIDAT84AS	132 column printer 9600 baud serial 2K interface, graphics, and tractor		$1119.00
BIMBSAPLWTWC*	Apple Parallel Interface w/Cable		$75.00

**Sold only with printer*

COMPARE PRICES!!

ADDS

Applied Digital Data Systems Inc.



SALE!
Green Screen $525.00
Black & White $479.00

VIEWPOINT — ADDS

Detachable keyboard, RS232 interface and auxiliary port, 80 x 24 display, tiltable screen.

BIADDVWPR	ADDS 3A, P31 Green Phosphor	$699.00	$525.00
BIADDVWPRBW	P4 Black & White	$699.00	$479.00

(Shiping Weight 30 lbs.)

VISUAL 50

- *Low profile detached keyboard features sculptured keys with matte finish*
- Screen tilts and swivels
- 80 x 24 display with 25th status line
- 7 x 9 dot matrix with full decenders
- RS-232 Serial interface w/auxillary RS-232 port
- 128 Character ASCII set and 31 character line drawing set

INTRODUCTORY OFFER!!

BIVSL50BW	Non glare Black & White	$695.00	$650.00
BIVSL50GR	P31 green display	$750.00	$685.00

(Shipping Weight 37 lbs.)

SEND $1.00 TODAY FOR THE NEW, FULL COLOR SPRING 1982 ENGINEERING SELECTION GUIDE!

Tandon

Tandon TM-800 Thinline is exactly half the size of conventional 8" floppy disk drives

ONE

Exactly one-half the height of any other model.
Proprietary, high-resolution, read-write heads patented by Tandon
D.C. only operation - no A.C. required
Industry standard interface.
Three millisecond track-to-track access time *(9 lbs.)*

BITNDTM8481	Single Sided $380.00	2 or more	$370.00
BITNDTM8482	Double Sided $495.00	2 or more	$485.00

TANDON 5¼" DRIVES

BITNDTM1001*	Single Sided, 250KB (5 lbs.)	$ 195.00 ea
	2 or More $180.00	
BITNDTM1002*	Double Sided, 500KB	$295.00 ea.
	2 or More $270.00	
BITNDTM1003	Single Sided, 500KB	$295.00 ea.
	2 or More $270.00	
BITNDTM1004	Double Sided, 1000KB	$395.00 ea.
	2 or More $375.00	

**As used in the IBM P.C.*

MITSUBISHI ELECTRIC



Better Than QUME! Better Than SHUGART!

8", Double-sided, double-density, interchangeable with OUME & Shugart

BIMITM289463	Sh. Weight 16 lbs.	$495.00
BIMITM289463 M	Manual	$ 10.00

2 or More $475.00 each

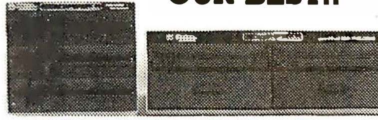
Shugart 801R

Single sided, double density - most popular 8" drive

BISHU801R	$394.00 ea. or 2 or more (16 lbs) for	$389.00
BISHUSA801RM	Manual for 801R drives	$ 10.00

INTERNATIONAL INSTRUMENTATION, INC.

OUR BEST!!



UNIVERSAL DISK ENCLOSURES

• *Accepts any combination of 8" drives (QUME/Shugart 801R type or ½ size Tandon type)* • *Also accepts hard disks* • *Positive pressure* • *Optional Disk environment monitor shows supply voltage and internal cabinet temperature* • *Internal power and data cables provided.*

UNIVERSAL DRIVE CABINET complete with power supply, fan and filter, and all internal cables for attachment of two 8" floppy drives.

BIIIUDE004	Dual Drive Cabinet (Sh. Wt. 40 lbs)	$495.00	$450.00
BIIIUDE004	With purchase of two 8" Disk Drives		$399.00
BIIIUDE004EM	w/Environmental Monitor installed	$584.95	$535.00
BIIIUDE004EM	With purchase of two 8" Disk Drives		$ 85.00
BIIIUDE004AUG	Dual Drive cabinet with Augmentation power supply module to increase 5V supply from 6 amps to 9 amps for use with two hard disks or 4 Tandon drives. Also includes Disk Environment Monitor (45 lbs.)	$733.00	$650.00
BIIIUDERCK	19" Rack Mount kit UDE004		$ 89.95

THIN THREE DRIVE CABINET complete with power supply, and all internal cables for attachment of three thin 8" floppy drives (Tankdon type). One AC power connector is also provided for use with full size drive.

BIIIUDETT	Three Drive Cabinet (Sh. Wt. 35 lbs)	$495.00	$450.00
BIIIUDETTTEM	with Environmental Monitor installed	$584.95	$535.00

5" CABINETS - VISTA

BIVIS9801	Single 5" with P.S.	$ 85.00
BIVIS9802	Dual 5" with P.S.	$110.00



9161 DEERING AVE • CHATSWORTH, CA 91311

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5464

Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs, plus 25¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through September, 1982. Credit Card orders will be charged appropriate freight. If you haven't received your Spring '82 Engineering Selection Guide, send $1.00 for your copy today!. Sale prices are for prepaid orders only.

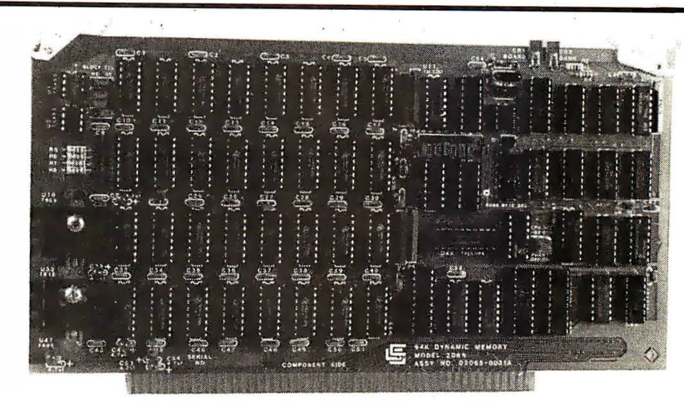
Circle 379 on Inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604

SPECIAL PURCHASES!



64K IEEE-S100 DYNAMIC MEMORY CARD



- 2 or 4 MHz operation
- Designed to IEEE proposed S-100 bus standards
- Supports IMSAI-type front panels
- Operates with either an 8080 or Z-80 based S-100 system providing processor-transparent refreshes with both
- Bank-select system allows system memory expansion
- Bank-select port's address is jumper selectable
- Any 16K block can be made bank-independent
- All 64K can be made bank-enabled on power-on and reset
- Fully buffered address and data lines
- Configuration as a 16K, 32K, or 48K board without the removal of RAMs
- Fail-safe refresh circuitry for extended Wait States
- Board configuration with reliable easy-to-configure Berg jumpers
- Supports DMA
- Jumper-selectable Phantom inplut
- Uses Popular 4116 RAMs
- Assembled & tested
- All ICs in sockets
- Full Factory Warranty

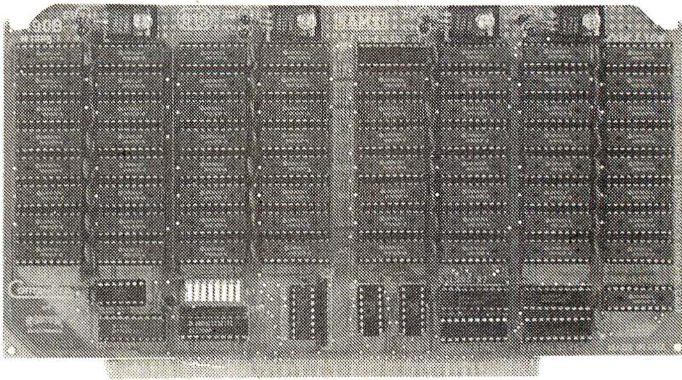
SAVE $130.00!!

BICCS20653
SHIPPING WEIGHT 2 lbs.
LIST PRICE: $350.00
SAVE $130.00!!

$249.00 ea or 4/$880.00

CompuPro SYSTEMS RAM 21

128K 12MHz S-100 STATIC MEMORY 8 OR 16 BIT



The days of "Out of Memory" are gone at last! CompuPro has introduced the largest static S-100 IEEE/696 RAM board ever to be produced.

The RAM 21 is arranged either as a 128K x 8 bit wide or 64K x 16 bit wide board, using a high speed, ultra low low power proprietary static RAM. CompuPro has also included 24 bit addressing for up to 16 megabyte capability and power consumption so low your mainframe will never know it's there!

- Meets or exceeds all IEEE 696/S-100 specifications
- Fully static design uses less power than dynamics (1.2 amps typical)
- 24 bit extended addressing
- 8 bit (128K) or 16 bit (64K) operation
- Addressable as one block
- 16K window deselect, dip switch selectable
- Switch selectable PHANTOM disable
- 12 MHz CPU operation
- 16K x 1 static RAM
- Thorough bypassing of all supply lines
- Capable of DMA processing
- 128K Static, 1.2 amps
- NMOS high speed low power memory ICS

BIGBT190A
List Price: $1695.00

SALE PRICE:

816

$995.00

SAVE $700.00!!

Circle 380 on inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604

PRIORITY ONE ELECTRONICS



WE JUST BURNED TANDON'S PRICE SHEET!

SPECIFICATIONS:	TM100-1
TPI	48
Tracks/Diskette	40
Capacity Per Side (unformatted)Double Density	250KB
Access Time	
Track-to-Track	5 ms
Average	75 ms
Head Settle Time	15 ms
Mechanical Dimensions: Width: 5.75 in. Height: 3.25 in. Depth: 8.00 in.	
DC Voltage Requirements:	+12/+5
Current Requirements	900mA/ 600mA

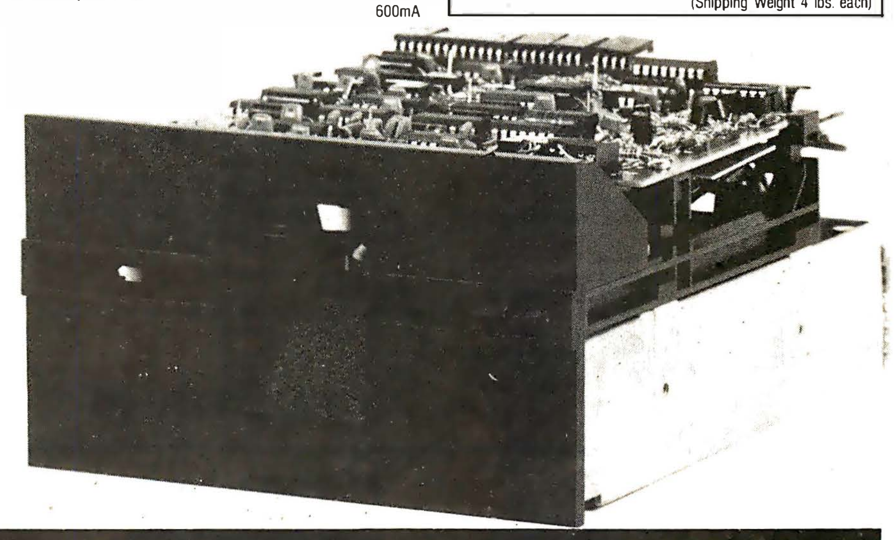
BITND1001 Bare Drive

Qty	Price
1	$195.00 ea.
2 - 9	$180.00 ea.
10 - 24	$170.00 ea.
25+	$160.00 ea.

OEM and Dealer Inquiries invited
(Shipping Weight 4 lbs. each)

Priority One Electronics has burned up Tandon's price sheet with our special purchase of Tandon TM1 00-1 5¼" 40 track double density disk drives! We purchased a large quantity of new, factory-sealed drives from a large OEM who simply bought too many. This is strictly a "one-shot" deal; when these are gone there will be no more! In fact, we are selling these drives below our regular cost as a volume purchaser! At these low prices, these drives will not last long! So, if you ever thought of expanding the disk capacity of your computer, now is the time!

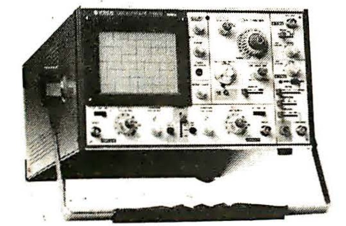
Tandon drives are known throughout the industry for their quality and reliability. That is why major computer manufacturers such as IBM have chosen Tandon drives for inclusion in their products. The TM1 00-1 is the same drive used in IBM's Personal Computer. Now you can add more disk storage to your PC and save hundreds of dollars! But you don't have to own an IBM Personal Computer to take advantage of this incredible Tandon sale! The Tandon TM1 00-1 has the industry standard interface for 5¼" drives so it is compatible with just about every computer on the market!



NO ONE CAN TOUCH US!

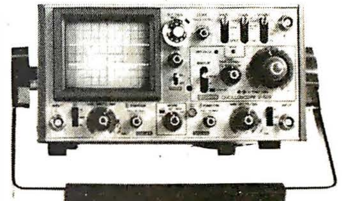
WE ARE THE NATION'S LARGEST  HITACHI DISTRIBUTOR

Hitachi Denshi, Ltd.



WE WILL BEAT ANY ADVERTISED PRICE ON HITACHI OSCILLOSCOPES!!

CALL FOR PRICES TOO LOW TO PUBLISH!!



HERE IS ONE EXAMPLE...

BIHITV550B
50MHz DUAL TRACE WITH 3RD TRACE TRIGGER VIEW
LIST PRICE $1745.00
SALE: $995.00

BIHITV1050
100MHz DUAL TRACE WITH 3RD & 4TH TRACE TRIGGER VIEW
CALL

BIHITV352
35MHz DUAL TRACE WITH DELAY

BIHITV202
20MHz DUAL TRACE
CALL

BIHITV302
30MHz DUAL TRACE INTERNAL DELAY LINE

BIHITV152
15MHz DUAL TRACE
CALL

BIHITV509
50MHz DUAL TRACE WITH CALIBRATED VARIABLE DELAY
CALL

BIHITV209
20MHz DUAL TRACE WITH 2 HOUR BATTERY BACK-UP
CALL

ACCESSORIES

BIHITDC1530	Dust Cover for V302 & V152	$35.00
BIHITDC2035	Dust Cover for HITV202 & V352	$35.00
BIHITFC5010	Front Cover for HITV550B & V1050	$18.00
BIHITAP5010	Accessory Pouch for HITV550B & V1050	$40.00
BIHITV1050M	HITV1050 Service Manual	$50.00
BIHITV152BM	HITV152B Service Manual	$50.00
BIHITV202M	HITV202 Service Manual	$50.00
BIHITV302BM	HITV302B Service Manual	$50.00
BIHITV352M	HITV352 Service Manual	$50.00
BIHITV550BM	HITV550B Service Manual	$50.00
BIHITSC5010	Vinyl Cover for HITV1050 & V550B	$30.00



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9161 Deering Ave., Chatsworth, CA 91311



ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5464

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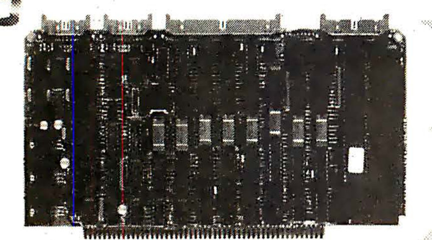
Circle 380 on Inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604

PRIORITY ONE ELECTRONICS



SIERRA DATA SCIENCES & MICROPOLIS™



SBC MASTER PROCESSOR WITH OPTIONAL MICROPOLIS 8″ WINCHESTER HARD DISK INTERFACE!!



SBC MASTER PROCESSOR

This is absolutely the most complete single board computer available; **NO EXTERNAL INTERFACE BOARDS ARE NEEDED!!**

- Z80A CPU
- 64K Bank Switchable Memory
- 4K EPROM
- Auto Boot
- NEC 765 FDC with PLL interface to all Shugart compatible drives (5¼″ or 8″)
- 2 RS-232C Serial ports (Z80ASIO, up to 19.2K BAUD)
- 2 parallel Ports (Z80 APIO)
- 4 Timers (Z80ACTC)
- IEEE 696/S-100 Compatible
- CP/M® and TURBODOS® compatible
- ALL SIERRA PRODUCTS CARRY A FULL ONE YEAR WARRANTY

The Sierra SBC was designed to meet the needs of single-user systems as well as multi-user systems in a number of configurations (i.e., Time sliced single processor operation, loosely coupled mlulti-processor operation, etc.) This flexibility provides SBC users with a natural growth path without the need to discard previous system components in most cases. In turn, users with larger requirements may build sophisticated multi-user systems right from the start.

An optional Intelligent Winchester Adapter allows the Sierra SBC to be interfaced to a Micropolis MicroDisk™. This allows the user to add reliable mass storage at a reasonable price.

As an added bonus during our September SALE, Priority One Electronics will supply the Sierra version of CP/M® 2.2 at no additional charge. **THAT'S A SAVINGS OF $200.00!!!**

BIPDBSBCCPM A&Tw/BIOS & CP/M® 2.2 List Price $1095.00

SALE: $895.00

SBC SLAVE PROCESSOR

Similar to above with 16K EPROM, X-Buss Expansion Interface and optional on board EPROM burner.

- Z80A CPU
- 64K Bank Switchable Memory
- 16K EPROM
- 2 RS-232C Serial ports (Z80ASIO, up to 19.2K Baud)
- 4 Parallel Ports (Z80APIO)
- 4 Timers (Z80ACTC)

BISDSSBCS Assembled & Tested List Price $795.00

SALE $750.00

SDS MICROPOLIS HARD DISK INTERFACE

Micropolis 1220/1260 microDisk series interface adapter with software drivers, cabling, and mounting hardware.

BIHSDSHDI Assembled & Tested **List $150.00**

MICROPOLIS 12631 45MB 8″ WINCHESTER DISK

The Micropolis MicroDisk is an 8″ three platter disk with 36 Mb formatted capacity. Winchester technology is incorporated in the Micro Disk design, which is packaged in two sections. The lower half, which contains the three platters, disk heads, and positioner, is completely sealed for years of reliable operation. The upper half, which is accessible for maintenance, contains four circuit boards, including the Micropolis intelligent controller. The drive is shock mounted in attractive Micropolis desk top enclosure with power supply.

BIMCP12631 Assembled & Tested List Price $6629.00

(Shipped Motor Freight Collect)

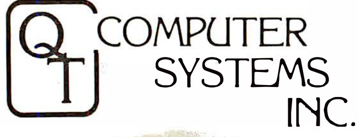
SALE $3995.00

SIERRA/MICROPOLIS SBC PACKAGE

Sierra SBC, CP/M, Micropolis Interface, and Micropolis 12631 MicroDisk.

BIPDBSBCSYSI Shipped Motor Freight Collect List Price $6629.00

SALE $4495.00





SAVE 20%

S-100 MAINFRAMES FOR DUAL 8″ HARD AND FLOPPY DISKS

The Q.T. MFD series mainframe is designed to be the most versatile and the most compact system enclosure on the market today. In addition to a 6, 8, or 12 slot S-100 card cage, the mainframe is designed to support two 8″ floppy or hard disk drives. It is ideal for the new generation of Single Board Computers and highly density RAM cards that do not require many slots. Now you can have a complete dual floppy or hard disk system in one convenient enclosure at a remarkably low price.

FEATURES:

- Accommodates any combination of standard 8″ floppy or hard disk drive (801R, DT8, Fujitsu hard disk, etc.)
- IEEE S-100 Silence+ 6, 8, or 12 slot motherboard available for quiet operation with high speed processors
- Keyed power Switch
- Reset Switch on Front Panel
- Anodized 6, 8, or 12 slot card cages
- Quiet fan with filter provides cool clean systems operating featuring positive air pressure
- Detachable line cord plugs directly into EMI noise filter for electrical noise suppression
- Two AC convenience outlets on rear panel for peripherals
- 15-DB25 cut outs for mounting I/O connectors
- 2-50 pin plug cut outs
- Dimensions: 9⅝″ x 17″ x 21″ (HxWxD) (Sh. Wt. 48 lbs.)
- Power Supply: +15@7A, +24V@7A, +8@ 18A, ±16@3A,-5@1A

Part No.	Description	List Price	SALE Price
BIQTCMFDD	without Motherboard	$600.00	$480.00
BIQTCMFDD6	with 6 slot Motherboard	$675.00	$540.00
BIQTCMFDD6	with 8 slot Motherboard	$700.00	$560.00
BIQTCMFDD12	with 12 slot Motherboard	$750.00	$600.00

QT MAINFRAMES SAVE 10%



MF+MD (Accepts 2 5¼″ Disk Drives)

Includes cabinet, IEE S-100 motherboard (6, 8, or 12 slot) and dual mini-disk provision with disk drive power supply. The hefty power supply is rated at +18V@18A, ±12@3A, and ±16V@3A. The QT MF+MD is fan cooled, has AC line filter to eliminate EMi, and is fully factory assembled and tested. Power and reset switches are located on the front panel. AC Convenience outlets, twelve DB25 cutouts and two 50 pin plug cutouts are on the rear panel.

Part No.	Description	List Price	SALE Price
BIQTCMFMD	without motherboard	$425.00	$382.50
BIQTCMFMD6	with 6 slot motherboard	$500.00	$450.00
BIQTCMFMD8	with 8 slot motherboard	$550.00	$495.00
BIQTCMFMD12	with 12 slot motherboard	$600.00	$540.00

The above mainframes are also available with an optional augmentation supply for 5¼″ hard disks; add the suffix **HD** to the above part numbers and add $150.00 to the price.

QT MF+

This cabinet is similar to above but without the cutouts for 5¼″ disks. Power Supply: +8V@18A, ±16V@3A

BIQTCMF	without motherboard	$400.00	$360.00
BIQTCMF8	with 8 slot motherboard	$450.00	$405.00
BIQTCMF12	with 12 slot motherboard	$500.00	$450.00
BIQTCMF18	with 18 slot motherboard	$550.00	$495.00

(Shipping Weight 40 lbs.)

QT SINGLE 8″ DISK CABINET

Accepts one 8″ *disk drive (Shugart, Remex, PerSci, Siemens, etc.). Fan cooled with AC line filter to eliminate EMI*

BIQTCDDCB	For single 8″ floppy disk	$250.00	$225.00
BIQTCDDCBH	For 8″ hard disk or tape streamer	$295.00	$265.50
BIQTCDDCBT	For 2 Tandon Thinline drives	$295.00	$265.50

(Shipping Weight 22 lbs.)

QT DUAL 8″ DISK CABINET

Capable of powering one Winchester hard disk and one floppy disk, simultaneously. Accepts two 8″ disk drives (Shugart or size equivalent) Fan cooled. (-5@1A, +5V@3A, +24V@3A)

BIQTCDDCBBH Horizontal Mount (Sh. Wt. 24 lbs.) $360.00 **$325.00**

CLOCK CALENDARS FOR S-100, APPLE, AND TRS-80



SAVE 10%

The Clock/Calendar + utilizes the popular MSM5832 real time Clock/Calendar chip designed for use in bus-oriented microprocessor applications. The 32.768MHz crystal controled time base will provide addressable 4-bit I/O dataof SECONDS, MINUTES, HOURS, DAY OF WEEK, DATE, MONTH, YEAR. the data access is controlled by a 4-bit address, read, write, and hold inputs. Z80 or 8080 compatible. 18 Month battery back-up on board.

Part No.	Description	List Price	SALE Price
BIQTCCCSA	S-100, A&T	$165.00	$148.50
BIQTCCCAA	Apple II, A&T	$150.00	$135.00
BIQTCCCTRS80	TRS-80, A&T	$150.00	$135.00

SBC2/4 Z80 S-100 SINGLE BOARD COMPUTER

The QT Computer SBC 2/4 Processor Board is a versatile and powerful Z80 based design which is compatible with the proposed IEEE S-100 bus standard. Although the SBC 2/4 may be used as the host CPU of a large system, it has all the necessary features to be used as a standalone computer system.

- Z80A 8 bit CPU
- 2 or 4 MHz Switch selectable
- 1K RAM (which can be located at any 1K boundary)
- One parallel I/O port
- One serial I/O port
- Power on jump to on board 1K or 2K boundary
- Full 64K use of RAM allowed in shadow mode
- DMA compatibility allows MWRT signal generation on CPU board or elsewhere in system under DMA logic or front panel control
- Two programmable timers available for use by programs run with the SBC+2/4 timer output and controls available for use on CPU board).

(Shipping Weight 2 lbs.)

BIQTCSBC24A Assembled & Tested $325.00 **$290.00**

Circle 381 on Inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604

PRIORITY ONE ELECTRONICS







NEW 4½ DIGIT HANDHELDS!

The FLUKE 8060A and 8062A offer the most powerful combination of capabilities ever in a handheld DMM, including these:

- 4½ digit resolution
- 10 μ V, 10mA, 10M sensitivity
- 100KHz True RMA (8060A)
- 30KHz True RMS (8062A)
- Relative Reference
- Constant current diode test
- Self diagnostics
- Basic DC accuracy of 0.04% (8060A); 0.05% (8062A)

The 8060A also offers dBm, relative dB, frequency measurements to 200KHz, Auto ranging megohms to300k , and conductance(2000 nS).

BIFLU8060A	with safety designed test leads	**$349.00**
BIFLU8062A	with safety designed test leads	**$279.00**

3½ DIGIT HANDHELDS: THE WORLD STANDARD

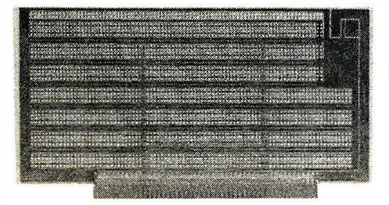
11 functions:

- dc voltage
- ac voltage
- dc current
- ac current
- resistance
- diode test
- conductance
- high-speed continuity beeper
- temperature (via K-type thermocouple
- peak hold on voltage and current functions 0.1% basic dc accuracy (8024B & 8020B) 0.25% basic dc accuracy (8021B & 8022B)
- visual logic level detection and continuity indicators

Extensive overload 3½-digit resolution protection with 600V double-fused current input. Safety-designed test leads. Two-year parts and Two-year labor warranty. Calibration Cycle.

BIFLU8024B	(All 11 functions)	**$239.00**
BIFLU8020B	(First 8 functions)	**$169.00**
BIFLU8021B	(First 7 functions)	**$149.00**
BIFLU8022B	(First 6 functions)	**$139.00**

page DIGITAL INC. NC Drilled Prototyping Boards



S-100 BOARDS

PART NO.	DESCRIPTION	PRICE 1-4	5-9	10-24
BIPGBP1001	S100 Bare Board	$15.95	$13.95	$11.95
BIPGBP1002	S100 Horizontal Busses	$22.95	$19.95	$17.95
BIPGBP1003	S100 Vertical Busses	$22.95	$19.95	$17.95
BIPGBP1004	S100 Pads Per Hole	$23.95	$20.95	$18.95

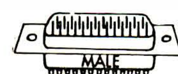
APPLE BOARDS

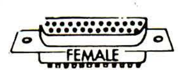
BIPGBP5001	Apple Bare Board	$15.95	$13.95	$11.95
BIPGBP5002	Apple Horizontal Busses	$22.95	$19.95	$17.95
BIPGBP5004	Apple Pads Per Hole	$23.95	$20.95	$18.95

GENERAL PURPOSE PLUGBOARDS

BIPGBP4411	4.5″x6″	22/44 .156″	Bare Board	$ 9.95	$ 8.95	$ 7.95
BIPGBP4413	4.5″x6″	22/44 .156″	Vertical Buss	$13.95	$12.50	$11.50
BIPGBP4414	4.5″x6″	22/44 .156″	Pads Per Hole	$14.95	$13.50	$12.50
BIPGBP4421	4.5″x9.6″	22/44 .156″	Bare Board	$10.95	$ 9.95	$ 8.95
BIPGBP4423	4.5″x9.6″	22/44 .156″	Vertical Buss	$14.95	$13.50	$12.50
BIPGBP4424	4.5″x9.6″	22/44 .156″	Pads Per Hole	$15.95	$14.50	$13.50
BIPGBP7211	4.5″x6″	36/72 .1″	Bare Board	$ 9.95	$ 8.95	$ 7.95
BIPGBP7213	4.5″x6″	36/72 .1″	Vertical Buss	$13.95	$12.50	$11.50
BIPGBP7214	4.5″x6″	36/72 .1″	Pads Per Hole	$14.95	$13.50	$12.50
BIPGBP7221	4.5″x9.6″	36/72 .1″	Bare Board	$10.95	$ 9.95	$ 8.95
BIPGBP7223	4.5″x9.6″	36/72 .1″	Vertical Buss	$14.95	$13.50	$12.50
BIPGBP7224	4.5″x9.6″	36/72 .1″	Pads Per Hole	$15.95	$14.50	$13.50

RS232 and "D" SUB-MINIATURE CONNECTORS





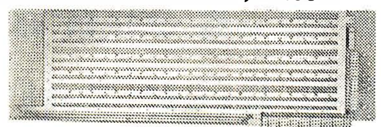
SOLDER TYPE

P=Plug, Male Type — S=Socket, Female Type — C=Cover, Hood

PART NO.	DESCRIPTION	PRICE 1-9	10-24	25-99
BICNODE9P	9 Pin Male	$ 2.10	$ 1.90	$1.70
BICNODE9S	9 Pin Female	$ 2.70	$ 2.40	$2.10
BICNODE9C	9 Pin Cover	$ 1.50	$ 1.25	$1.10
BICNODA15P	15 Pin Female	$ 2.75	$ 2.45	$2.15
BICNODA15S	15 Pin Female	$ 3.95	$ 3.60	$3.20
BICNODA15C	15 Pin Cover	$ 1.50	$ 1.30	$1.10
BICNDDA25P	25 Pin Male	$ 3.00	$ 2.75	$2.25
BICNDDA25S	25 Pin Female	$ 4.00	$ 3.75	$3.00
BICNODB51212	1 Pc. Grey Hood	$ 1.80	$ 1.45	$1.30
BICNOD25H	2 Pc. Grey Hood	$ 1.50	$ 1.25	$1.10
BICNODB51226	2 Pc. Black Hood	$ 1.90	$ 1.65	$1.45
BICNODC37P	37 Pin Male	$ 5.80	$ 5.10	$4.45
BICNODC37S	37 Pin Female	$ 8.70	$ 7.70	$6.70
BICNODC37C	37 Pin Cover	$ 1.80	$ 1.55	$1.30
BICNODD50P	50 Pin Male	$ 8.75	$ 7.75	$6.70
BICNODD50S	50 Pin Female	$11.85	$10.25	$8.90
BICNODD50C	50 Pin Cover	$ 2.00	$ 1.80	$1.60
BICNOD20418	Hardware Set 2/Pr RS232, DB25P, EIA	$ 1.00	$ .80	$ .70
BICNORS232BF	Class 1 Cable 8 Con 8 Ft	$19.95	$17.95	$15.95
BICNO573036	Cent. 700 Series/ Epson Printer Conn.	$ 9.00	$ 7.50	$6.00
BIIDC5730860	IDC Version of Above	$ 9.95	$ 9.00	$8.00

IBM

NEW FROM *Vector*



IBM* PC PROTOTYPING BOARDS

Part No.	Description	1-5	6-24	25'
BIVCT4613	3 Hole Solder Board	$59.00	$53.10	$47.20
BIVCT4613-1	Bare Board	$37.00	$33.30	$29.60
BIVCT4613-2	Wire Wrapping Board	$59.00	$53.10	$47.20
BIVCT3690-22	Extender	$22.35	$20.12	

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PRENTICE



THE STAR
OUR MOST POPULAR MODEM
We've Sold Thousands!

● 0 to 300 baud ● Bell 103 and 113 ● Exclusive tripel seal acoustic chamber ● Self Test ● ±0.3% frequency stability; crystal controller ● Receiver Sensitivity of -50dB on; -53dB off ● FSK Modulation ● RS232 Compatible ● **Switches:** Originate/Off/Answer: Full Duplex/Test/-Half Duplex ● **Indicators:** Transmit Data, Receive Data, Carrier Ready Test

Part No.	Description	List Price	SALE
BIPRNSTAR	RS232, TTI, 20Ma Current Loop	$199.00	**$127.00**

SEND $1.00 TODAY FOR THE NEW FULL COLOR, SPRING 1982 ENGINEERING SELECTION GUIDE

MICROCOMPUTER PRODUCTS

MEMORY

PART NO.	PRICE
BI4116AC20	8/$18.00
BI2016P3	8/$72.00
BI2114N3L	8/$28.00
BI5257N3L	8/$50.00
BI2732	8/$98.00
BI2716	8/$48.00
BI2708	4/$20.00

Z80 SERIES

BIZ80A	$13.39
BIZ80AP10	$11.19
BIZ80ACTC	$11.19
BIZ80ADMA	$33.39
BIZ80AS100	$39.95
BIZ80AS101	$39.95
BIZ80AS102	$39.95

UARTS

BIAY51013A	$5.95
BITR1602B	$4.95
BITR1863	$6.95
BIIM6402	$7.95

8080 SERIES

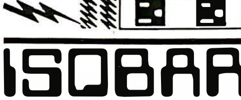
PART NO.	PRICE
BIINS8080A	$5.50
BIINS8085A	$19.95
BIDP8212N	$2.95
BIDP8214N	$5.25
BIDP8216N	$2.95
BIDP8224N	$3.25
BIDP8224-4N	$9.95
BIDP8226N	$3.50
BIDP8228N	$5.55
BIDP8238N	$5.55
BIINS8250N	$15.95
BIINS8251N	$7.50
BIINS8253N	$17.95
BIINS8255N	$6.80
BIINS8257N	$18.45
BIINS8259N	$18.00
BIINS8259N	$59.95
BIINS8275N	$59.95
BIINS8279N	$24.95

FLOPPY DISC CONTROLLER

BIFD1771B-01	$24.95
BIFD1791B-01	$44.95

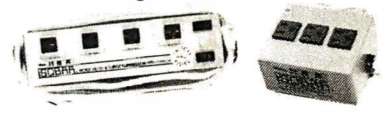
**PROTECT YOUR INVESTMENT
PROTECT YOUR DATA WITH**





ISOBAR

With Built-In Noise Filters and Surge Suppressors



ISOLATES SENSITIVE AND VALUABLE EQUIPMENT FROM: Equipment interaction - Damaging High Voltage Spikes - AC line noise and hash.
PROTECTS AGAINST: Voltage transients caused by lightning, contact switching, turn-off of inductive components, noise due to electro-magnetic coupling.
USE THE GSC ISOBAR TO ISOLATE: Microprocessor from peripherals - Lab instruments from noisy equipment - Sensitive pre-amp or tape deck from power amplifier.
THE GSC ISOBAR ELIMANATES: Equipment interaction - Equipment damage from power line spikes and surges - Errors - False printouts- Disk Skips - Audio or video hash
FEATURES: Inductive isolated ground - Sockets indivdually filter isolated - Circuit breaker protected at 15A.
VOLTAGE TRANSIENT SPIKE PROTECTION: 2000 A peak for up to 6 Sec duration spikes. 1000A, 8/20 Sec protection from repeated spikes.
LOAD HANDLING: 1875 W max. total load; 15A per socket.
INPUT: 125 VAC, 15 amps; standard 3-prong plug.

IBAR 3 - Three common outlets built-in circuit breaker, pilot light, hang-up bracket and a 6-foot cord.

		List Price	Our Price
BIGOFIBAR3	Sh. Wt. 3 lbs.	$59.95	**$42.00**

IBAR 46 - Four independently isolated outlets. Built-in 15A circuit breaker, pilot light, switch, and 6-foot cord.

BIGOFIBAR46	Sh. Wt. 4 lbs.	$79.95	**$49.95**

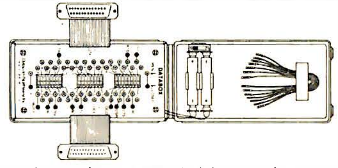
IBAR 86 - 8 outlets, grouped to form 4 independently isolated sets of two. Built-in 15A circuit breaker, on/off switch, pilot light.

BIGOFIBAR86	Sh. Wt. 5 lbs.	$84.95	**$54.95**

IBAR 9RM - Eight rear-mounted outlets grouped to form four independently isolated sets of two, plus one non-isolated convenience outlet on front face. 19″ rack mount cabinet. Built-in 15A circuit breaker, pilot light, on/off switch, and 6-foot cord.

BIGOFIBAR9RM	Sh. Wt. 6 lbs.	$99.95	**$74.95**

RS232 Breakout Box



A must for every technician, repair man or systems integrator

Databox is contained in a tough, plastic case and is powered by two, 1.5 volt penlight batteries. No power is consumed by the tester when not in use. Dimensions:2.9″x5.55″x1.45″. Weight: 10 oz. w/batteries.

BIONW232BOX	$199.00	**$159.00**

TI SPECIAL PURCHASE GOLD
16 PIN LOW PROFILE IC. C95 SOCKETS

BITIG16LP	package of 100	$16.00
BITIG16LP	package of 1000	$120.00

OEMS Stock up at this low price!!



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NEDA



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Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMU PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs., plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through September, 1982. Credit Card orders will be charged appropriate freight. If you haven't received your Spring '82 Engineering Selection Guide, sned $1.00 for your copy today! Sale prices are for prepaid orders only.

Circle 381 on inquiry card.

SEE IMPORTANT NOTICE ON PAGE 604

IMPORTANT NOTICE!

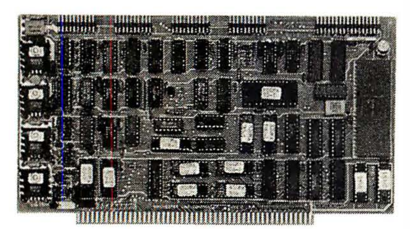
38% Price Increase Next Month BUT YOU CAN BEAT IT!!

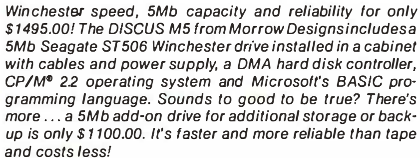
Effective with the next issue in October, B TE is raising its advertising rates 38%. Did you know that it costs $4300.00 to run a full page ad in B TE?* With the new rates, that cost will jump to $5,950.00 per page* As high as that sounds, BYTE is still the best value in the industry; both for advertisers and for readers. As BYTE's circulation continues to grow, so do the costs of paper and postage. Since 1977, B TE's cost of paper has increased 40% and postage has increased by a whopping 175%! As you can guess, *these high advertising costs will be passed on to the public in the form of higher prices.* It will be difficult for us, or for any advertiser, to offer sale prices on special purchases or to advertise small parts in our monthly ads. For example, we could not offer the Morrow Designs DISCUS M5 at $1495.00 under the new rates. We will, however, continue to run our six to eight pages of advertising each month because our sales from BYTE are consistently ten times higher than from any other magazine we've advertised in. We have no plans to stop offering special sales or to stop selling small parts. On the contrary, they will continue to be featured in periodic sale flyers and in our semi-annual catalog. But to receive these catalogs and flyers you must be on our mailing list. *To get on our mailing list, all you have to do is circle the reader service number that appears at the bottom of this page on your Reader Service post card.* You will then be assured of receiving the latest information on new products, special purchases, and all-around good deals! In the mean time, look over the many specials in our nine pages of ads this month; you may never see prices like these again!

CIRCLE NUMBER 527 ON READER SERVICE CARD

**Figures based on full page black & white ad; one time insertion rate. These rates may vary depending upon ad frequency and position.*

5Mb S-100 HARD DISK SUB-SYSTEM $1495.00
5Mb S-100 HARD DISK BACK-UP $1100.00*

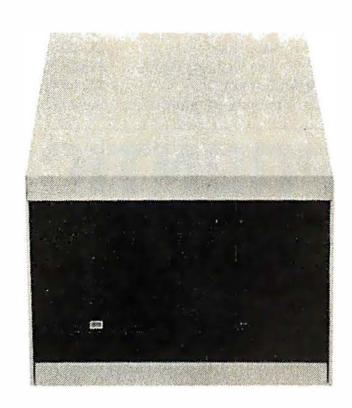




Winchester speed, 5Mb capacity and reliability for only $1495.00! The DISCUS M5 from Morrow Designs includes a 5Mb Seagate ST506 Winchester drive installed in a cabinet with cables and power supply, a DMA hard disk controller, CP/M® 2.2 operating system and Microsoft's BASIC programming language. Sounds to good to be true? There's more ... a 5Mb add-on drive for additional storage or back-up is only $1100.00. It's faster and more reliable than tape and costs less!

KEY FEATURES:

- Storage capacity of 6.38Mb unformatted; 5.0Mb formatted
- Band actuator and stepper motor head positioning
- 5.0 megabit/second transfer rate
- Same track capacity as a double density 8 inch floppy
- 170 millisecond random average access time, reduceable to 95 ms via a simple software algorithm
- The only single S-100 DMA Hard disk controller board on the market today
- Fully compatible with high speed 6MHz and 8MHz CPUs of today and tomorow
- DMA bus arbitration as outlined by the IEEE 696 standard
- Controls 1 to 4 soft sectored Winchester drives
- ST506 or SA 1000 interface compatible
- Variable sector length (256,512,1024, or 2048 byte sectors)
- Automatic CRC generation and checking
- Addresses 1 to 16 heads
- Addresses an infinite number of tracks
- Contains its own on-board microprocessor — Signetics 8X300
- 24-bit address burst DMA transfers
- Channel driven for enhanced speed
- All disk driver routines resident on the controller
- Variable format
- No buffering required
- Maximum transfer rate 5,000,000 bits per second
- Due to this high transfer rate, a minimum CPU speed of 2.5MHz is required

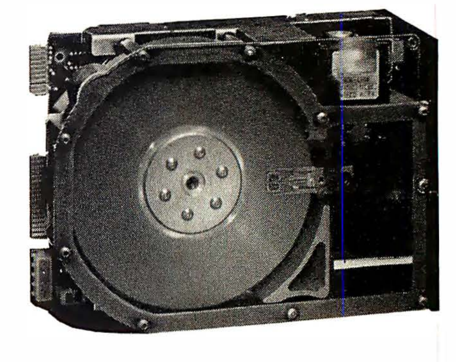


The DMAHDC has been designed for expansion. One to four drives can be attached directly and controlled. One to sixteen drive heads may be addressed. Any number of tracks may be specified during the seek routine by specifying one to two hundred and fifty-six tracks one or more times. Each of the expansion abilities prepair the user to upgrade his system as technology advances to additional platters and tracks.

DISCUS M5 WITH DMA HARD DISK CONTROLLER

BIMDSDMAM5	Software supplied on 8" IBM3740 disk with blank I/O and INSTALL program
BIMDSDMAM52B	Software configured for Morrow DJ/2B controller and Mult I/O as console
BIMDSDMAM5DMA	Software configured for Morrow DJ/DMA controller and Mult I/O as console

CIRCLE OUR READER SERVICE NUMBER!!



BIMDSDMAM55S	Software supplied on 5¼" soft sector (IBM/Cromemco disk w/blank I/O and INSTALL program	
BIMDSDMAM5NS	Software supplied on 5¼" 10 sector North Star disk with blank I/O and INSTALL program	
DISCUS M5	5Mb Subsystem	List Price $2195.00

SALE PRICE $ 1495.00

(order by part numbers listed above; shipping weight 17 lbs.)

DISCUS M5 ADD-ON DRIVE

MDSADM5	5Mb Add-On Drive	List Price $1845.00

SALE PRICE $1100.00*

**With purchase of above M5 subsystem or with previous purchase of M5 subsystem from Priority One Electronics. Proof of prior M5 purchase required with order.*







ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5464

Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through September, 1982. Credit Card orders will be charged appropriate freight. If you haven't received your Spring '82 Engineering Selection Guide, send $1.00 for your copy today! Sale prices are for prepaid orders only.

Circle 527 on inquiry card.

Unclassified Ads

FOR SALE: Original IMSAI 8080 S-100 mainframe, processor board, front panel 20-A supply, 12K RAM, 4-port parallel I/O, 22-slot motherboard, universal cassette interface, extender board, Cromemco color TV Dazzler, Polymorphic Systems black-and-white TV interface, Wameco EPM-2 EPROM board, Smith KBD-3 encoded keyboard, RF modulator, complete documentation of all boards and 8080 manuals, and software on paper tape for 8080 and Dazzler. Will accept best offer. Roger French, 1170 Parkview Dr., Marion, IA 52302, (319) 377-6255.

FOR SALE: BYTE #1; $10 or best offer. Kilobaud Microcomputing #1, 2, 3, 4, 5; $5 or best offer each. Clive Frazier, POB 972, Windermere, FL 32786.

FOR SALE: Teletype Model 43 30-cps dot-matrix printer terminal, RS-232 interface, pin feed, and Hall-effect keyboard. In good condition. $800 or best offer. Richard Rostrom, 7344 North Hoyne, Chicago, IL 60645, (312) 973-5064 evenings, 927-5510 days.

WANTED: FORTRAN compiler or interpreter for Apple II Plus to be used in teaching introductory course. Limited language subset acceptable and graphics ability desirable. Institutional license required. Avery Catlin, POB 3726, Charlottesville, VA 22903, (804) 924-3337.

WANTED: Info Terminal Communications' of Raleigh, North Carolina, Video Terminal Model TC275. D. Boone, POB 330, Valley Mills, TX 76689.

FOR SALE: 48K Apple II with two disk drives and manuals. Xerox 1730 printer and tractor feed. Virtually brand new. Best offer over $4500. F. O'Neill, 154 East 46th St., New York, NY 10017, (212) 599-5845.

FOR SALE: Sanyo 9-inch monitor in excellent condition. Best offer takes it. I will pay first-class shipping and insurance. Chuck Miller, 7th USAAD, APO NY 09169.

WANTED: Old-style Memory Plus circuit board manufactured by the Computerist. This board contains 8K bytes of 2102-type RAM and sockets for EPROMs. It was made for the AIM/SYM/KIM type microcomputer. Jerry Stoker, 8325 Krim Dr. NE, Albuquerque, NM 87109, (505) 821-3354.

FOR SALE: North Star Horizon computer with 32K, two quad-density floppy-disk drives, two serial and one parallel ports, North Star DOS and BASIC (factory assembled). $2100. Intertube terminal with printer port, graphics, and full keyboard with numeric pad. $500. Centronics 103 printer with bidirectional dot matrix, 132-column tractor feed, two character sizes, 165 cps, and RS-232C interface. $400. All in excellent condition with manuals. All offers considered. Bill Novak, 12 Mechanicsville Rd., Granby, CT 06035, (203) 529-2550 8-4 ET.

FOR SALE: Microace computer with 8K ROM and 2K RAM options, assembled and tested, for $125. Price includes shipping. Postal money order only please. David M. Hofmann, 389A Dyer Dr., FPO San Francisco 96630.

FOR SALE: S. D. System S-100 boards. SBC-100, Expandoram I 64K, and Versafloppy II disk controller. $250 each or $700 for all three. Also have an Altair 680B 6800 microcomputer with 16K static RAM. $150 each for microcomputer or 16K RAM board; $275 for both. E. Cummins, 5124 Walden Mill Dr., Norcross, GA 30092, (404) 447-9060.

WANTED: Apple II (48K) with Autostart ROM, Applesoft card, compatible disk drive and controller (preferably Apple), black-and-white 13-inch monitor, joysticks, and compatible printer. All must be in good to excellent condition. Items may be separate from different individuals. Send model year, purchase price, and asking price. Bob Koskovich, Organization COMPU, 125 East Hermosa Dr., San Gabriel, CA 91775.

FOR SALE: Surplus electronic components: resistors, capacitors, transistors, crystals, switches, LEDs, panels, knobs, potentiometers, PC boards, diodes, rectifiers, etc. Also have about 150 ICs and 40-pin unidentified Intel chip. Will sell any or all for 25% of list. Please write or call as soon as possible. Steve Riley, 30 Kim Court W, Westerville, OH 43081, (614) 891-4986 or Phillip Drayer, 6342 Freeman Rd., Westerville, OH 43081, (614) 882-4930.

FOR SALE: Processor Technology SOL-20 with 48K RAM, Helios II dual 8-inch disk system, 12-inch monochrome video monitor, Digital Equipment LA-180 DECprinter I with serial interface, PTDOS Version 1.5 disk operating system, Extended Disk BASIC and FORTRAN, and instruction manuals. $4000 without DECprinter; $6000 with DECprinter. Patrick J. Edwards, 1600 West Crosby, Slaton, TX 79364.

GERMANY: Computer hobbyist (6800, WH-89, S-100) seeks friends near Frankfurt with interest in hardware/software and local/remote networks. Also have lots of hardware to swap and sell: 8-inch floppy-disk drives, modems, VDUs, hard disks, 9-track tape drives, card reader, keyboards, monitors, character- and line-printers, scopes, and more. I am looking for a letter-quality printer and old EDP stuff like core memories, type elements, pcbs, hammer modules, hard-wired ROMs, etc. Defects are okay. Also looking for programs: games, utilities, data management, etc., for Heath H-89 (CP/M + HDOS), 5- and 8-inch. Rolf Petersen, 06003-7455 evenings and weekends.

WANTED: Student experimenter just starting in computers desperately seeking advice how to implement KIM/SYM-1 microcomputers for robotics use. All replies will be greatly appreciated. Brian Jacoby, RR 1, Box 157, Vesta, MN 56292.

FOR SALE: MITS Altair 8800b mainframe, dual double-density Shugart SA-400 drives, 38K of static RAM, quad parallel ports, triple serial ports, Heathkit H-19 smart video terminal, Heathkit H-14 smart line printer, CP/M 2.0, North Star 5.0 DOS/Monitor/BASIC, and miscellaneous hardware/software. Fully integrated, functional, with all documentation. $3500 (package only). G. Godden, 18401 67th West, Lynnwood, WA 98036, (206) 776-6124.

FOR SALE: Godbout S-100 desktop computer enclosure with Godbout 20-slot motherboard and CVT power supply. Bought new last summer. Never used. Will accept reasonable offer. S. Dimitroulias, 191 Hempstead St., New London, CT 06320, (203) 443-1398 (no collect calls).

FOR SALE: First two years of BYTE; $120 or best offer. First three years of Kilobaud Microcomputing; $108 or best offer. First seven Bug Books, one through five; $35. All in like-new condition. L. Chambers, 4530 Sheridan St., Davenport, IA 52806.

WANTED: LNW-80 owners to write me. User group interests; possible software exchange. Interests are high-resolution graphics, animation, cartooning, A-D-A, and music. Don Ball, POB 72, Saline, MI 48176.

FOR SALE: PET stuff: IEEE-488 auto answer/originate modem TNW-103; $150. PET to S-100 interface, supports DMA Inc. Dazzler; $100. S-100 box, 22-slot bus, and power supply; $75. Two S-100 8K memory boards; $75 each. Dazzler color graphics board; $100. Everything for $400. Larry Shaw, 215 Hazel Ave., Mill Valley, CA 94941, (415) 383-1092.

FOR SALE: 24K Atari 800 with 810 disk. DOS I plus extra disk in three-ring binder with vinyl disk holders. BASIC, Super Breakout, and Star Raider cartridges. RF adapter, two joysticks, and set of paddles. All support documentation plus Atari's newsletters. $1300 or best offer. Cliff Fuhrmann, 1833 35th St. NW, Rochester, MN 55901, (507) 286-1842.

FOR SALE: HP-9815 with RS-233 option. Has the diagnostic tapes with an extra tape for personal use. Totally operational with very small amount of operating time on it. Approximately four years old. $1000. Richard Grancorvitz, Norland Corporation, Rte. #4, Norland Dr., Fort Atkinson, WI 53538, (414) 563-8456 or 563-9145.

FOR SALE: Ohio Scientific C3A with 48K, OS65U operating system, and two Siemens disk drives. Also, Intel SDK-51 8051 microcomputer development tool, assembled and working. Best offers. Neal Enzenauer, 2180 Old Hwy. B, St. Paul, MN 55112, (612) 780-4880.

FOR SALE: TRS-80 accessories. Percom data separator; $15. Percom Doubler I with documentation and DBLDOS without double-density disk chip; $30. Double Zap II, double-density patch for NEWDOS/80 V1 with documentation and original disk; $20. Radio Shack Modem I, 300 bps/originate only/acoustical coupler; $75. All items guaranteed working/postpaid. Kerry Chesbro, 13605 115th Ave. NE, Kirkland, WA 98033, (206) 821-2042 evenings.

FOR SALE: S-100 hardware. Integrand 800D desktop mainframe with 15 connectors, eight RS-232 cutouts, and 15-A power supply; $300. SD Expandoram I with 16K 4116 RAM, 2 MHz; $200. SSM VB1-B 64 by 16 video board; $150. SSM P8-I 2708/2716 PROM programmer; $150. Jade P/S I/O with one parallel port and two serial ports (one is cassette); $100. Must sell; prices negotiable. Douglas Zimmerman, 2824 St. Paul St., Baltimore, MD 21218, (301) 889-1698.

FOR SALE: Three Okidata Model CP110 bidirectional 5 by 7 dot-matrix printers. Parallel I/O, 110 cpi, 70 lpm, 80-character buffer, frictionfeed, 80-column, 6-bit ASCII code, uppercase, and punctuation. Roll paper or single sheet. $300 each. Danny Kile, 534 Elden Ave. NW, Roanoke, VA 24019, (703) 366-4480.

FOR SALE: Super Elf 1802 computer. Fully expandable S-100 computer. Excellent starter system. Includes Lo Address option and standard case. Full documentation. Three months old; in good condition. Call for more information. $100 or best offer. Alex Segal, 17 Fox Run Rd., Bedford, MA 01730, (617) 275-7534.

WANTED: SwTPC computer, disk, and cassette I/O. Send description and phone number. Kearney Hill, 1027 Whittier, Emporia, KS 66801, (316) 343-1915.

WANTED: 48K Apple II with autostart ROM. One disk drive with a 3.3 controller card. A black-and-white or color monitor, or an RF modulator. For a 15-year-old paying for it himself (so unfortunately it would have to be paid for a little at a time on an unset payment basis until I can get a job this year). Kerwin Thomas, 1528 Kinsdale St., Philadelphia, PA 19126, (215) 224-8645.

FOR SALE: 22-slot motherboard from OT Systems installed in Vector CCK-100 card cage; $180. Eight new and two used Vector prototyping boards (8800V) for $13 each. Also, integrated circuits in limited quantities: 20 74LS670s and 25 74LS645-1s for $2 apiece. All prices do not include postage. Jack C. Carden, POB 1317, Lake Dallas, TX 75065, (817) 497-2083.

FOR SALE: 16K static RAM board; $150. Vector Graphic 2K EPROM, 1K RAM board; $75. Heuristic Speechlab with microphone; $100. All works well. Richard DeMayo, 7852 Bartholomew Dr. NE, North Ft. Myers, FL 33903, (813) 997-3047.

FOR SALE: Radio Shack Model 1, Level 2 with 16K ($849), With 16K expansion interface ($499), two mini-disk drives ($1000), Base 2 Inc. Model 800 printer ($649), desk for equipment ($50), Visicalc ($100), one Budget Management ($24.95), Standard & Poor's Stockpak system ($49.95). Used only six months. Cost $2520; make offer. Walter H. Niles, 101 Country Ridge Dr., Port Chester, NY 10573.

UNCLASSIFIED POLICY: Readers who are soliciting or giving advice, or who have equipment to buy, sell or swap should send in a clearly typed notice to that effect. To be considered for publication, an advertisement must be clearly noncommercial, typed double spaced on plain white paper, contain 75 words or less, and include complete name and address information.

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Please note that it may take three or four months for an ad to appear in the magazine.

Unclassified Ads

WANTED AND FOR SALE: I need a single-density minifloppy for the North Star Horizon. For sale or trade, ASR33 Teletype with paper-punch unit. Ron Magazzu, 126 Highfield Lane, Nutley, NJ 07110.

FOR SALE: OSI C1P (Model I) software. Programs include fast arcade games, utilities, and tiny compiler etc. from Aardvark. They are on original cassette tapes complete with all instruction/documentation. Total cost of the 12 programs was $150; will sell for $75. Joseph Liu, 808 West 2nd Ave. #2, Chico, CA 95926, (916) 893-4310.

WANTED: Goodwill. Student without pride or money looking for handouts. I am desperate for a start in electronics and computers. I need used, surplus, out-of-date, or damaged equipment (circuit boards, terminals, printers, computers, TVs, radios, any electrical or mechanical parts), documentation, schematics, magazines, etc. Write or call me and I will make the shipping arrangements. Scott A. Jones, 8095 North Meridian St., Indianapolis, IN 46260, (317) 251-6499 evenings.

WANTED: I live in a remote area of Michigan and own a TRS-80 Model II. I would like to correspond with other TRS-80 Model II owners. James R. Young, POB 336, Ludington, MI 49431.

WANTED: Young, poor, but talented independent software developer (recent computer-science graduate) looking for wonderfully cheap microcomputer hardware and software to work with and build on. Send offer with full description. Jim Talley, 929 Dumaine St. #5, New Orleans, LA 70116.

FOR SALE: 1200 bps modem (Anderson Jacobson ADAC 1200). Operates either acoustically coupled or directly connected. Documentation included. $275. Tom Alexander, 333 A St. NE, Washington, DC 20002, (202) 547-0355.

FOR SALE: Hewlett-Packard HP-85 computer. Please mail your best offer, name, and telephone number. You can pick it up in New York City or receive it by mail. Dr. Gregory M. Hunter, 35 Stevens St., Danbury, CT 06810.

FOR SALE: Digital Group Z80 Bytemaster fully integrated computer with 64K dynamic memory, detachable keyboard, built-in monitor, and single-density 5¼-inch disk drive. Prewired for up to four 5¼- or 8-inch disk drives and for a parallel port to printer. Very expandable. Excellent condition. DISKMON, BASIC, assembler, and disassembler. Full documentation and two boxes of disks. Best offer over $1500. Brent Dowd, 5289 South Manitou Rd., Littleton, CO 80123, (303) 797-7512.

FOR SALE: Carterphone Selectric terminal with Worldwide ASCII conversion. Mechanically okay, but has some electronic glitches (will not execute ASCII carriage return consistently from Apple II; shift key occasionally hangs keyboard). Sold as is. First certified check or money order for $350 gets it; will ship freight collect. Herb Rand, POB 136, Sweet Briar, VA 24595.

FOR SALE: Digital Group 32K dynamic-memory board; $225. I/O parallel board; $25. Video interface (64 by 16) and audio interface; $75. Motherboard with some connectors; $20. Two Phi-Decks and controller; $200. Z80 processor board; $50. Phi-Deck and audio software; $50. Also, 12A-5V ovp power supply; $75. Jeff Ryder, 1983 McKelvey Hill Dr. Apt. E, St. Louis, MO 63043, (314) 878-6620 after 6 p.m.

FOR SALE: TRS-80 Model I, Level II with 16K, cassette recorder, and instruction manuals. Best offer. G. Zaybal, 5810 Buck Court, Westmont, IL 60559, (312) 387-5934 days, 964-1551 after 5 p.m.

FOR SALE: Intel 8086 microprocessor chips at one-third the normal price. 16-bit, prime, and unused. I have 10 of these left over from a project. $30 each. Programmers' manuals; $4 each. Bob Rockinson, RD #1 Malden Rd., Coal Center, PA 15423, (412) 938-7050.

WANTED: Could anybody send me a copy of the three-part article "APL Interpreter for Microcomputers" (BYTE August, September, and October 1977 and corrections in November and December 1977) and information about building APL interpreters in general (especially for the 6502)? This is a cry for help because in Austria I won't get any support of this kind! Wolfgang Nitsch, Pacassistr. 28, A-1130 Vienna, Austria.

FOR SALE: IMSAI 8080 microprocessor complete with front panel, case, power supply, 22-slot motherboard with 14 edge connectors already soldered, IMSAI MPU 8 processor board, and MITS 4K RAM. Fully burned-in and tested. Complete with original documentation and manuals. Never used, hence, in brand-new condition. Best offer/$500. Peter Ksiezopolski, 8200 Boulevard East, North Bergen, NJ 07047, (201) 869-8448 evenings.

FOR SALE OR SWAP: TRS-80 Color Computer program packs: Quasar Command, Project Nebula, Skiing, Chess, Bustout, Music, Pinball, Personal Finance, and Color File. Plus on tape: Pyramid (adventure), Quest (semiadventure), and Star Trek (game). Original price $335. Will sell for $167.50. All new in original boxes. Will send C.O.D. (or send check or your listing). Bland's Nursery c/o Shane Bland, Hwy 54 West R.R. 3, Linton, IN 47441, (812) 847-9427.

BOMB

BYTE's Ongoing Monitor Box

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BASIC Wins BOMB

Our congratulations to Thomas E. Kurtz for his article "On the Way to Standard BASIC," which captured first place in the June BOMB results. The first-place prize of $100 is on its way to the author. A very close second place goes to Rod Daynes for "The Videodisc Interfacing Primer," a concise guide to developing your own interactive videodisc programs. Rod will receive the second-place award of $50. Jerry Pournelle's User's Column and Steve Leibson's Input/Output Primer, Part 5: Character Codes share the honors for third place.

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Article No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Excellent	801	805	809	813	817	821	825	829	833	837	841	845	849	853	857	861	865	869	873	877	881	885	889	893	897
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Fair	803	807	811	815	819	823	827	831	835	839	843	847	851	855	859	863	867	871	875	879	883	887	891	895	899
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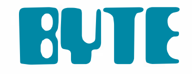
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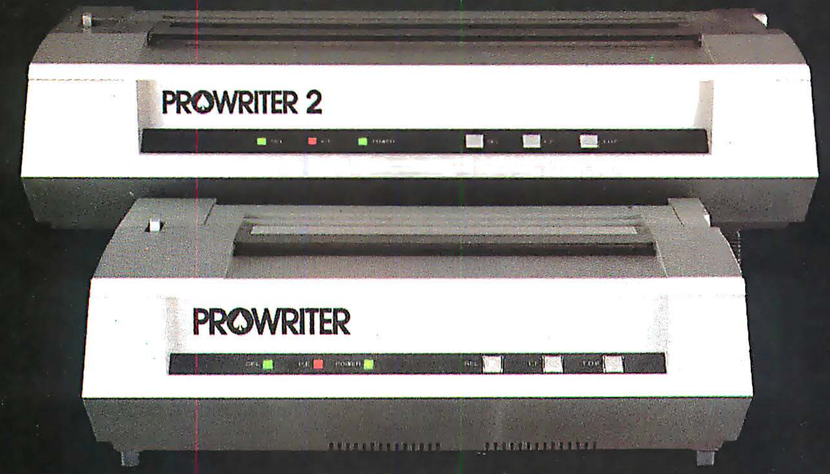
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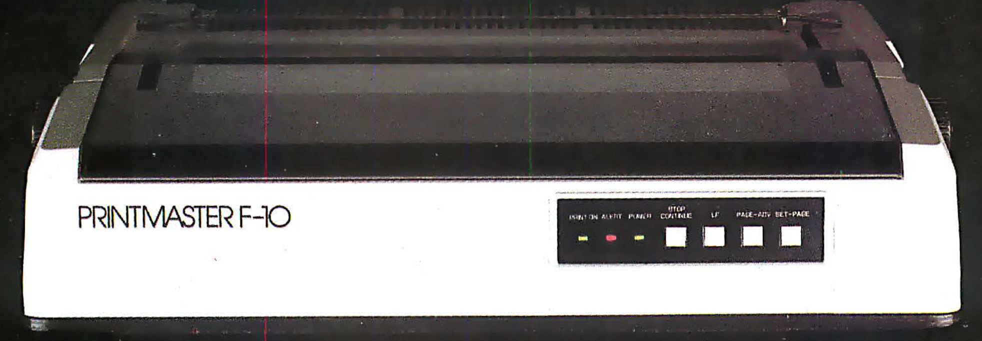
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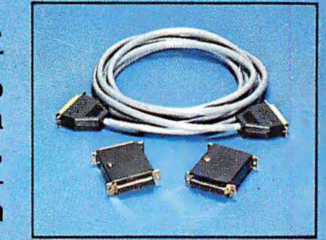
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